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# IMPACT of science on society

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# FOREWORD

"World Energy Resources and the Production of Power" was the theme of the Fourth World Power Conference held in London, July 10-15, 1950. As almost all the papers read at this Conference will interest anyone concerned with the impact of science on daily life, we give a complete list of the papers on page 79 These papers, together with records of the discussions bearing on them, will be published in the Transactions of the Conference and will be available through the World Power Conference, 201 Grand Buildings, Trafalger Square, London, W.C.2., England. Those who wish to obtain single papers or supplementary information on them may send their requests to the National Committees of the World Power Conference (see list, page 85).

The breadth of the problem of "Energy in the Service of Man" is such that this issue of IMPACT has been planned solely as an introduction to the question. Consequently, only abstracts of papers of general interest at the Fourth World Power Conference will be found in this issue, together with abstracts of papers and publications dealing with the problem along general lines, such as Martin Ruhemann's Sigma book on "Power". A reference list of films on "Energy" is also given.

No attempt has been made, or should be made, in our opinion, to abstract Niels Bohr's Open Letter to the United Nations. Each word counts in this historic document on the impact of science on sociéty. It will be found in full on page 68

The Editor

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# ENERGY IN THE SERVICE OF MAN

**by Sir Harold Hartley, C.B.E., F.R.S.**

The wheels of society are kept turning by energy. There is no aspect of everyday life that is not concerned with the use of energy – whether it is the food we eat or the coal, oil and water on which we rely for heat and power. It is only a hundred years since we first understood the meaning of the word "energy", yet the history of the material progress of mankind has been the history of its use – the discovery of fire, the raising of crops, the forging of tools and weapons, the invention of machines. To-day, with the steady rise in world population and its crying need of more food and higher standards we are acutely aware that the future of the human race is more than ever dependent on the right use of energy.

Yet to-day there is a world shortage of power, and an uneven distribution of power resources between the northern and the southern hemispheres. We must find new ways of creating power and of increasing its production from existing sources if we are to maintain, let alone increase, the existing standards of living in every country.

The Fourth World Power Conference, of which I was Chairman, met last week in London to discuss the papers from its National Committees on "World Energy Resources and the Production of Power". It could not, I think, have met at a more opportune time, and it is good news that UNESCO is to follow up its work next year with its discussion theme of "Energy in the Service of Man".

Last week's Conference brought together more than 1300 engineers and scientists from forty countries to examine, on an international level, how this growing demand for energy can best be met, and to exchange and pool their knowledge of all sides of fuel technology. The meeting took place under the shadow of another war, and the thoughts of many of the older members turned to the founder of the World Power Conference, Daniel Nicol Dunlop, and to how the organisation came into being. This Scottish electrical engineer had watched the destruction of the first world war, on a scale only made possible by the brilliant work of scientists and engineers. He then determined to see what they could accomplish working together for the benefit instead of the destruction of mankind. As a result the First World Power Conference was held in London in 1924, and the organisation can now look back on a history of twenty six years of fruitful and co-operative work.

The Technical Sessions last week were grouped under three headings:- the energy resources of each country, the preparation of fuels and the latest developments in the production of power.

The discussion on energy resources showed that the world reserves are sufficient to meet the rising demands for coal for centuries and for oil for some decades, but it revealed the great inequalities of their distribution between nations, marking their dependence on one another. It revealed too the rapidly increasing use of natural gas by countries fortunate enough to possess it, and the rapid harnessing of water power.

Great improvements have been made since 1924 in the efficiency of the four great energy industries, coal, electricity, gas and oil. There is now great need for a similar improvement in the utilization of the products they provide. In this way it should be possible to meet much of the world's increasing demand for energy without drawing more heavily on our reserves.

One outstanding point in the discussions on the preparation of fuels was the rapid progress in the methods of oil refining and in the manufacture of synthetic fuels from coal and natural gas.

The sessions on power production covered the latest developments both in hydro-electricity and in the generation of electricity by means of steam turbines, where the most advanced plants are reaching the limits set by the properties of the alloys now available.

There were also sessions dealing with the most modern types of oil and petrol engines and with the prospects of gas turbines and turbo-jets.

A session of particular interest dealt with new developments in the field of energy. The heat pump-the refrigerator in reverse – is now under trial in several countries.

It is a device for extracting heat from the ground or water with a high energy efficiency Italy now has a large power station using volcanic steam. France is experimenting with a turbine dependent on the difference in the temperature of the surface and deep water of tropical seas. There are new developments coming in the use of wind power.

The final session on the peaceful use of nuclear energy was a historic occasion. For the first time a number of experts from different countries met for open discussion of their views. It was clear from what they said that there are many engineering problems to be solved before it will be possible to say whether nuclear power will be competitive with steam and hydroplants. All the experimental and development work required must inevitably take a considerable time. It would be a tragedy for the world if enthusiasm for the great potentialities of nuclear energy in the future should delay in any way the development of the more conventional and better understood sources of the energy, which the world needs so sorely to-day. But nuclear energy should make it possible in time to bring power to places far from energy sources, like the Sahara, and thus open new vistas of development.

Many of the speeches at the Conference expressed in various ways the conviction that energy is the key to so many of the problems the world is facing to-day. Power is the multiplier of human effort. It is essential to increased production both in the factory and on the farm. In any plans for the development of more backward countries, implementing President Truman's Fourth Point, energy may well prove to be the limiting factor. Their needs are transport, irrigation, heat and power and the skill to use them.

Energy has been the key to progress through the ages and it has not lost its power. This is the keynote of UNESCO's discussion theme next year. It will bring home to everyone the need to use energy efficiently, with care and for the common good.

(This is the text of a broadcast recorded specially for UNESCO by Sir Harold Hartley on the occasion of the Fourth World Power Conference in London, July 1950.)

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# ENERGY IN THE DEVELOPMENT OF CIVILIZATION

**by Dr. LESLIE A. WHITE, Professor of Anthropology at the University of Michigan**

Human civilization is about one million years old. During this long course of time, civilization has grown from the level of our pre-human ancestors to the same status in which we find it today. We know a great deal about the process of development of this civilization. Our knowledge of this development has come mainly from three sources: First, from archeological exploration of extinct civilizations - or of extinct cultures, to use the term preferred by anthropologists; second, from the study of primitive peoples still living in the modern world; and, third, from investigations into the nature of man himself. On the basis of this total knowledge we are able to formulate a theory that will explain the growth of civilization thus far, will make clear to us the status of civilization as it exists today, and will, we hope, give us some indication of its probable course in the future.

Man, like all other animals, is engaged in a struggle for existence. This struggle takes place not only between man and his natural habitat, but within the human species itself - between tribes and nations. Civilization, or culture, is the means employed by man to carry on his struggle for survival.

Culture is made up of many things. It includes tools and weapons, customs and institutions, ceremonies and rituals, art, science, philosophy, religion, and so on. An essential feature of culture is its continuity; for a large part of the culture of one generation or age is passed on to the next. Culture is thus a continuous process which grows and develops in accordance with principles of its own. We are able to formulate the laws of this development. And the basic law relates to energy.

All living organisms require energy. In order to maintain their existence, organisms must be able to control and to utilise energy in one form or another. In the human species, culture is the characteristic means of harnessing energy and of putting it to the service of man's needs. By means of tools and weapons, social organization and knowledge, man is able to harness the forces of nature and to put them to work for him. It follows, therefore, that as more and more energy is harnessed, the more highly developed does the culture become. When only a small amount of energy is controlled per capita, the culture will be low; man will be a savage or a barbarian. If, however, the amount of energy harnessed and put to work be great, the culture will be high.

We see therefore that civilization has developed because ways and means have been found from time to time to increase the amount of energy per capita under man's control and at his disposal for culture building. This is the fundamental law of the growth of civilization.

The first source of energy to be utilized in culture building was the human body. The amount of energy that can be obtained from human bodies is, of course, small. It is equivalent to only about one-tenth horsepower per adult male. When all its members were considered, including infants, the weak, and the aged, the carliest human society had no more than about one-twentieth of one horse-power per capita. Naturally, the culture, or civilization, built with these meager resources, was exceedingly low and crude. And mankind would have continued to live in this primitive condition indefinitely, had not a way been found to increase his energy resources - to harness and control more energy per capita.

The first really great step in cultural advance was taken when man learned to domesticate animals and to cultivate plants. This happened some twelve to twenty thousand years ago. Plants and animals are, of course, forms of energy - solar energy stored up in cellular form.

And when man harnessed these natural forces through animal husbandry and agriculture — especially agriculture — he greatly increased the energy resources at his disposal for culture building. As a consequence, there was a great increase in population; villages grew into cities, and tribes into nations and empires. More and more people were freed from the labor of food production as agriculture became more efficient and their time and talents were devoted to the arts, crafts, and professions. Architecture, metallurgy, writing, mathematics astronomy, the fine arts, and philosophy advanced rapidly in the hands of specialists. It is significant to note that after hundreds of thousands of years of slow progress in the Old Stone Ages, civilization leaped forward and progressed rapidly following the introduction of the agricultural arts - in ancient Egypt, Mesopotamia, India, China, and, in the New World, in Mexico, Middle America , and Peru.

The second great step in cultural advance was taken only a century or two ago when solar energy was again harnessed, this time in the form of coal oil and by means of steam and internal combustion engines.

And today we are on the threshold of a third stage of cultural advance: that of harnessing the energy of the nucleus of the atom.

The social systems of mankind are closely related to their underlying technological systems - to the ways in which energy is harnessed and put to work. Thus, a people, who derive their subsistence wholly from hunting and gathering wild plant food, will have one type of social system. A pastoral or an agricultural people will each have another type, and an industrialized people still another type of social system. Social systems are always determined by the

amount of energy harnessed per capita, and by the ways in which this energy is expended in gaining a living from nature and in waging offensive and defensive competition with neighboring systems.

The introduction of agriculture brought about a social revolution as well as a technological revolution. It destroyed the clan and tribal system of primitive peoples and instituted civil society with the political state. The recent technological revolution powered by coal and oil has likewise inaugurated a series of great social changes that has not yet run its course. But today we are confronted with this entirely new development: atomic energy. The age-old struggle to conquer and subdue the forces of nature has at last harnessed a power so great as to become a threat to man's existence, at least as a civilized being.

At the same time, atomic energy offers a promise of peace and abundance in the ages to follow.

(Reproduced with permission from "The Scientists Speak", Edited by Warren Weaver and published by Boni and Gaer, New York, 1947).

105 ADVANCEMENT OF SCIENCE, BRITISH ASSOCIATION FOR : *Supply and Utilisation Of Coal.* The Advancement of Science, v. 5, 17, p. 38-48, 1948.

A synopsis of a series of discussions and papers from the British Association's annual meeting at Dundee in 1947. They comprise, from the section of Geology, a group of nine papers on 'The Future of Coal Supplies'; from the Physics section, a symposium by seven speakers on 'Coal as a Source of Heat and Power'; a paper from the Engineering section on the mechanization of collieries; and a discussion on 'Man and the Machine', which was arranged by the sections of Physiology, Anthropology and Psychology, and in which attention was given to the working conditions of the miner.

106 AHMED, ABDEL AZIZ : *Water-Power Resources of Egypt.* Fourth World Power Conference, London. Paper A. 25.

In this report a general survey is made of the water-power resources of Egypt, which include chiefly the Aswan Dam, Qattara, and Second Cataract hydro-electric schemes. The main object of the report is to deal with some outstanding technical and economic features of these schemes. The former scheme is under construction, and the last two are under study. On the constructional side, various methods of feeding the turbines from Aswan Dam are discussed, with special reference to their effect on the safety of the dam. On the economic side, the utilization of the energy available from Aswan Dam Station, in the creation of two basic chemical and steel industries, is discussed, and forecast is given of its distribution to the various consumers. The Qattara scheme is explained in some detail, and the results arrived at in a preliminary survey are briefly stated.

107 ALGERIAN NATIONAL COMMITTEE : *Energy Resources and the Development of Power Production.* Fourth World Power Conference, London. Paper A. 17.

So far, no complete list of the energy

resources of Algeria has been compiled. In practice, however, coal mines at Colomb-Béchar and Kanadsa are being exploited commercially, and the output in 1948 amounted to 226,000 metric tons of coal. Researches in connexion with petrol are also in progress. In 1948 the production of hydro-electric power was about 100 x $10^6$ kWh.; in 1949 it was 145 x $10^6$ kWh. and it is expected to reach 325 x $10^6$ kWh.; in 1952. Sources of hydro-electric power totalling more than 1 x $10^9$ kWh. have been surveyed.

108 AUSTRALIAN NATIONAL COMMITTEE : *Energy Resources and Power Developments.* Fourth World Power Conference. London. Paper A. 3.

The report deals with the energy resources of Australia and the territories of Papua and New Guinea. As far as large-scale operations are concerned, the indigenous resources for the production of energy are confined to coal and water power. As the coal position has to a very great extent remained static over recent years, and as few of the improvements made in the economic use of coal are peculiar to Australia, the greater part of the report deals with water power.

109 BEAU, Ch. & NIZERY, M.: *Industrial Utilization of the Differences of Temperature between the Deep and the Surface Waters of the Sea.* Fourth World Power Conference, London. Paper K. 3.

By bringing together the surface waters of the oceans, whose temperature reaches 28° C (82° F) in tropical countries, and cold waters from the depths at 8° C (46° F), a thermal potential corresponding to huge quantities of energy is obtained. The French Government has initiated an investigation into the harnessing of this energy at Abidjan, on the Ivory Coast, where the first electric plant of this kind is being built. The thermodynamic cycle consists in evaporating under vacuum part of the warm surface waters at 28° C. The steam is "inhaled" by the condenser, which is cooled by the deep waters, and on the way it passes through a turbine that drives an electric generator. Every problem involved in the undertaking has been solved, and it can be said now that only classical and tested processes will be used for the construction. From the economic viewpoint the thermal energy of the sea compares very favourably with its senior, hydro-electric energy. Furthermore it could be used as a source of energy for evaporating plants in chemical industries and in artificial salines.

110 CADLE, AUSTIN : *Petroleum and the Growth of the Pacific Coast.* The Scientific Monthly, v. 69, 5, p. 334-7, 1949.

The growth in population of the American Far West (11,000,000 in 1939; 15,000,000 in 1949; 17,000,000 in 1954) and the general economy have been based upon a foundation of rich natural resources. The main source of energy is petroleum (approximately 70 per cent), natural gas (approximately 22 per cent), hydroelectric power (approximately 4 per cent), and coal only about 5 per cent.

111 CANADA : DOMINION WATER & POWER BUREAU & OTHERS : *Energy Resources of Canada and their Development.* Fourth World Power Conference, London. Paper A. 2.

The paper briefly reviews the energy resources of Canada under headings of water power, coal, oil and natural gas, with tabulations of production and reserves. Water power is shown to be the principal source of energy in Canada. A brief history of the development of these resources since 1924, includung graphs, is given in the concluding section.

112 CHEMICAL ENGINEERING REPORT : *Process Energy.* Chemical Engineering, v. 57, 5, p. 103 - 150, 1950.

This survey of the U.S. situation consists of four main parts, including in

all 14 articles. The first section is statistical and in two articles deals first with energy supply, availability and cost, then with the actual share of all principal fuels and electricity that was consumed by various process industries in the typical year of 1947. The second section, in a group of three articles, is concerned with energy sources and resources, particularly from the long-range viewpoint, and with today's newest fuels, natural gas and liquefied petroleum gases. The third section, in six articles, discusses energy production and application and goes into the question of power generation vs. purchase, as well as into process steam and prime movers, plant power distribution and conversion, and refrigeration. The last section, in three articles, deals with energy conservation. Its subjects include waste heat recovery by heat exchange, and by the heat pump, as well as economy in cooling water.

113 CHILEAN NATIONAL COMMITTEE : *Energy Resources of Chile.* Fourth World Power Conference, London. Paper A. 18.

Chile is divided into seven geographical regions, with different kinds of power resources, especially where water power is concerned, owing to the fact that the rivers in the nortnern half of the country are of a glacial type, while those in the southern part depend on rainfall for their flow. Coal is found in both submarine and subterranean seams. The total proved reserves are $61.5 \times 10^6$ metric tons, and the total reserves are estimated to be $698.5 \times 10^6$ metric tons. Coal production between 1912 and 1948 has increased from 1,330,000 to 2,270,000 metric tons. Petroleum was discovered at the end of 1945, near the Magellan Straits. At present six geological structures likely to yield petroleum have been investigated. The water-power resources are great. The generation of electricity has steadily increased during the last twenty-four years. In 1924 it was 160 Wh per inhabitant, and had risen to 500 Wh in 1948. A programme of development of water-power resources by means of State-owned plants is being carried out. In the south, Chile possesses vast forests. Other possible sources of power are those of volcanic origin, i.e. hot springs, and those of tidal energy, solar energy, and wind energy. It is calculated that in 1924 the total consumption of energy was $4,312 \times 10^6$ kWh, while in 1948 the figure had reached $6,641 \times 10^6$ kWh. In 1924, the corresponding consumption for each inhabitant per year was 1,113 kWh, while in 1948 it was 1,170 kWh.

114 CLAUSEN. H.E. *The Problem of Efficient Burning and Utilization of Vegetable Wastes and Similar Fuels.* Fourth World Power Conference, London, 1950. Paper E4. 6.

A situation is rapidly developing which will compel the use of the lowest grades of fuels to avoid a total depletion of those supplies which contain a large amount of energy in a small volume, and which must consequently be kept in reserve to meet situations of real emergency. This means that available world fuel supplies must in the future be obtained an and consumed in accordance with the general economic interests of all nations. We must find methods which will enable us - even at a higher initial cost - to use efficiently the fuels which are available in the regions where energy is needed, regardless of any special demands of local industry.

The future predominance of the low-grade fuels seems to be inevitable. They can be obtained more easily and even if they contain fewer calories in a given volume and also sometimes present certain difficulties in their practical application they appear to be the key to future progress. From the hardwood trees, requiring 400 years' growth before they can be economically felled in present circumstances, down to the grass and vegetable "plagues" (which can produce up to 20 tons of dry cellulose per hectare in a season), it seems indisputable that the future of cheap energy production still

lies in the miracle of the chlorophyll molecule.

This does not mean that we shall discard the production of low-cost atomic energy power in the future. We are, however, inclined to consider such production, for the time being, rather as a valid excuse for producing energy as an expendable by-product of the atomic pile, whose fundamental reason for existence lies in the fact that it is capable of concentrating a tremendous amount of energy in a small space or time, but not at a low cost.

It seems advisable to promote a larger co-operation between countries, and to sponsor:- (1) An agreement to establish clear and distinctive denominations of the various kinds of combustion equipments; (2) Exhaustive studies to increase the efficiency at low cost largecapacity dryers, to make it economic to burn, with the highest efficiency, waste materials from industries which produce fuels having a high percentage of moisture, such as sugar-cane, sugar-beet, alcohol-distilleries tannin-extraction plants, etc; (3) Further investigations into the functioning of cyclonic-type burners or combustion chambers (system 3), similar to those already used since 1944 in the U.S.A and Argentina, in order to make them generally applicable; (4) Investment of ample funds to encourage the study of combustion of all fuels in improved atmospheres, using a higher percentage of oxygen than is contained in normal air. This seems to be the field in which the largest possibilities of improvement exist, because the increased efficiency might surpass any other figure, even in combustion systems actually in use, particulary in the field relating to the utilization of low-grade fuels; and (5) Co-ordinated studies dedicated to finding means for applying the wasted calories of many industries to the production of cheap steam for others. For example: waste gases of glass and cement factories for the production of low-pressure steam for laundries, wool-washing plants, dye-houses, etc.; utilization of very high-temperature processes to generate high-pressure steam for other purposes, such as could be provided by the calcium-carbide cooling operation and other processes.

115 COCKCROFT, J.: *The Development of Power from Nuclear Energy.* Fourth World Power Conference, London. Paper J. 1.

The first development of nuclear power is likely to come by the transfer of heat from a nuclear reactor to a conventional power-generating system. The following are the principal technical problems which will be faced in the course of the nuclear power development programme:- high-temperature operation; high heat transfer rates; neutron economy and breeding; long operating life; development of economic chemical processing methods; and disposal of radioactive waste. Each of them must be solved if the programme is to succeed. The building of the first experimental reactors will probably occupy the next three to five years. During the following five years we may expect to be gaining operating experience and to be designing the first full-scale nuclear power producers. At least the same length of time will probably be needed for the necessary chemical engineering and metallurgical developments required to produce economical processes. We are unlikely therefore to embark on any large-scale development of nuclear power before at least a decade has passed.

116 COX, H. ROXPEE : *The Gas Turbine - New Prime Mover.* The Times Review of the Progress of Science, p. 12-13. Published as a supplement to The Times, April 1950.

The author reviews probable trends in development of the gas turbine from the point of view which is most relevant to the present theme. He concludes that for non-aeronautical purposes the gas turbine has only a very limited future in Great Britain unless it can be developed to run on cheap fuels - notably coal and peat. The latter is of potential

importance, particularly in view of the hope that, in the opon cycle application, the steam produced in the drying of the peat can be used in the engine to augment its power.

117 CRAMMER, J.L. and PEIERLS, R.E. (ed.): *Atomic Energy*. Pelican Books, 1950

Sir John Cockcroft concludes that pilot plant operation is required before it can be said that some of the problems to be solved are soluble, and this is likely to occupy the next 10 years. It is unlikely that any appreciable part of world power will come from nuclear sources in the following decade, and attention should not be diverted from pursuing in parallel the many other methods by which fuel economy can be achieved and world fuel resources increased.

118 CZECHOSLOVAK NATIONAL COMMITTEE : *Energy Resources and Power Development in Czechoslovakia since 1924*. Fourth World Power Conference, London. Paper A. 15.

The principal source of energy in Czechoslovakia is coal . The water-power resources supply only a small part of the energy required, and in the future this proportion will not change to any great extent. A constant tendency towards the use of lower-grade coal is noticeable, and this is causing developments in furnaces of special design. This paper deals with the data and characteristic features of solid fuels, water power, electrical energy, and gas in Czechoslovakia.

119 DANIELS, FARRINGTON : *Solar Energy*. Science, v. 109, 2821, p. 51-7, 1949.

'From the dawn of history man has realized the importance of the sum, but only in the present scientific age has he begun to appreciate the vastness of this source of energy and the extraordinarily clever mechanisms by which nature makes efficient use of it.' We can call on the sun to help us find still more food, fuel ans power - but the road ahead is challenging. The author deals with: the amount of solar energy; utilization of solar energy; and efficiency of photosynthesis and its mechanism.

120 DAVIDSON, W.F.: *Nuclear Energy for Power Production - II*. Fourth World Power Conference, London. Paper J. 3.

The technical problems that must be solved before nuclear reactors for the generation of power can be built successfully, are proving to be more difficult than was expected three years ago. The programme of the United States Atomic Energy Commission provides for the construction of four reactors, which are expected to go a long way toward answering many of these problems, but it will be at least two years before the first of them is in full operation. The estimated cost ranges from 80 to 100 million dollars. Even when the technical problems have been solved, it is not to be expected that the cost of power can be much below that for coal- burning or hydro-electric power plants, unless operation is on a multi-purpose basis in which a large part of the costs is allocated to other operations such as the production of bomb materials. Safety considerations and disposal of radio-active wastes add considerably to the general costs.

121 DOUMENC, R.A.M.; *Underground Gasification of Coal*. Fourth World Power Conference, London. Paper D2. 3.

French research work on underground gasification is now concerned with three activities:- share taken in the international experiment at Bois-la-Dame (Belgium); underground field experiments at Djerada (Eastern Morocco); theoretical work and experiments conducted at the Montluçon Research Station. The present paper relates technical information obtained from the last two activities. At Djerada the aim is to obtain generator

gas from anthracite. Field work consists of a horizontal panel on the rise between two slopes in the coal; arrangements are made so as to preheat blown air; oil burners are used for preheating the coal mass before ignition. First experiments conducted from August to November 1949 have indicated the necessity to blow air under a fairly high pressure, and revealed problems involved by such a pressure, as well as thermal inertness of the rocks. It has been necessary to interrupt the first test for long-duration combustion, although preheating and ignition had been a success.

At the Research Station, investigations on scale models have enabled a qualitative representation of the process to be obtained, particularly with respect to the fire setting and the displacement of the fire zone; the influence of width of gas jet and of calorific losses has been found. More theoretical research, checked, however, by experiments, has provided information on the order of magnitude of the losses through the mass, and on the influence of rock moisture. A study of the kinetics of the reduction of carbon dioxide by a coal wall is now proceeding; up to the present, it has been proved that above 1,200° C (2,190° F), diffusion is the only factor limiting the process practically; hot runs should therefore be particulary favourable.

122 EGERTON, A.C.G.: *Power and Combustion.* 25th Thomas Hawksley Lecture of the (British) Institution of Mechanical Engineers. Proceedings of the Institution of Mechanical Engineers, v. 144, p. 110-124, 1940.

Available world sources of energy are discussed in relation to their ultimate origin. This is solar in most cases, and power utilisation is in part alternative and in part complementary to utilisation as food, which itself acts in part as a source of man-power. Energy sources are considered (e.g. volcanic and oceanic) which as yet have been only slightly used or not at all.

123 ELCE, NORMAN: *Atomic Energy.* Fourth World Power Conference, London. Paper J. General Report.

The comments of a mechanical engineer on the five papers on atomic energy presented in Section J. He investigates some mechanical problems which may determine the form, the detail, and the cost of the atomic energy power plant.

124 ENGEL, LEONARD : *Gas from the Mine.* Scientific American, v. 182, 6, p. 52-54, 1950.

A description of the large-scale experimental project being carried out in Alabama (U.S.A.) for converting underground coal into useful combustible gases. The process, which is also being pursued actively in several European countries, involves the firing of a section of a coal seam, with the rate of combustion carefully controlled. Vertical pipes, running from ground level down into the horizontal coal shaft, serve to admit air for supporting the combustion and also to draw off the product gases.

If the experiments prove to work out as successfully as present experience indicates, several advantages will accrue: the energy yield will be greater than that from conventional mining, many poor-quality deposits will be made available for exploitation, transportation costs will be lowered, and the dirt and unsightliness of coal mining will be eliminated.

125 EVE, RICHARD and WESTON, J.C.: *The Economics of House Heating.* Journal of the Royal Institute of British Architects, v. 51, p. 12-26, 1948.

The authors describe the unoccupied stage of the Abbots Langley experiment in full-scale domestic heating (mentioned in abstract 160.)

126 FEDERATION OF BRITISH INDUSTRIES : Fuel Economy Review, Silver Jubilee Number, v. 25, 1946.

Contributions include :- Industrial Uses of Fuel Oil; Progress in Industrial Fuel Practice (Sarjant, R.J.); Twenty-Five Years of Progress in the Gas Industry (Alexander, J.R.W.); Industrial Electric Lighting To-day (Robinson W.); The Recovery of Industrial Waste Heat (Critchley, G.N.); The Use of Pulverised Coal (Bannister, W.J.); A Smoke Eliminator for Natural Draught Lancashire Boilers (Hurley, T.F.); Non-Productive Coal Consumption in Steam Raising (Hider, G.E.); Electricity Supply as a Factor in Securing Fuel Economy (Beard, J.R.); The Need for a Practical Classification of British Coals (Allfrey, G.C.); and Coal Utilisation Research (Colville-Wallis, R.).

127 FIES, M.H., and ELDER, JAMES L.: *Underground Gasification of Coal.* Journal of the Institute of Fuel, v. 23, p. 50-52 1950.

Condensation of paper presented at the (1949) United Nations Scientific Conference on the Conservation and Utilisation of Resources. The authors consider the promising potentialities of underground gasification of coal as a method of obtaining low-cost synthesis gas, as a source of cheap fuel for power generation, and as a method of utilizing coal veins difficult or uneconomical to mine. An earlier field-scale experiment at Gorgas, Alabama, together with laboratory experimentation, led to a larger project, also at Gorgas, which is still in progress.

128 GOLDING, E.W.: *Large-Scale Generation of Electricity by Wind Power, Preliminary Report.* British Electrical and Allied Industries Research Association Technical Report, C/T 101.

The author discusses the potentialities of electrical generation from wind power, with particular reference to Great Britain. Problems of storage are discussed, and the importance of choice of site emplasized. The largest such generator known to have been operated was a 1250 kilowatt experimental plant built on a hill in Vermont, U.S.A., by the S. Morgan Smith Company. Much research is required before the most economic form can be determined. It is tentatively estimated that from several hundred sites in Great Britain a total annual energy output of between 3.75 million and 7.5 million kilowatt hours might be obtained. Development is being continued.

129 GOLDING, E.W.: *Electricity from the Wind.* Discovery, v. 11, 3, p. 97-98, 1950.

A summary discussion in article form by the author of the previous reference.

130 GREGOR, ALADAR : *Energy Resources and Prime Movers in Hungary Since 1924.* Fourth World Power Conference, London. Paper A. 21.

Knowledge of the energy resources of Hungary shows a substantial increase since 1924, both in regard to the quantities of reserves, and because of the discovery of new sources of energy, namely, oil fields and methods of utilizing low-head water powers. Among energy sources of mineral origin, the various kinds of coal account for 91.25%, peat for 8.2%, mineral oil for 0.4%, and natural gas for 0.15% of the total reserve, calculated on the basis of calorific value. The greater part of the calorific value of the known coal reserve exists in the form of black coal and good-quality brown coal, whereas lignites of poor quality, representing one-half of the total reserves, do not exceed one-quarter of the total calorific power. The main objects of further development in coal production, which is contihually increasing are the formation of mining centres, further prospecting and mapping, and gradual mechanization, including frontal cutting. The yield of the oil fields which were opened up in 1937 completely meets the home demand, and even leaves a surplus for export. Of the natural gas rising to the

surface together with the oil, 20% is pumped back into the soil, whilst the rest is partly utilized in the neighbourhood of the oil fields, and partly conveyed by a pipe line to Budapest for supplying consumers there.

Of the forests, 77% are controlled by the State Forestry, the main objects of which are the creation of new forests, and the increase of annual yields by the introduction of rapidly growing species of trees. The theoretical reserve of water power, which is exclusively of a flat-land character, is 1.1.x $10^6$ kW, with a possible annual yield of 7,500 x $10^6$ kWh. In order to make use of the water power, it is proposed to construct, within thirty years, four hydro-electric power stations along the river Tisza, two or three along the Danube, and a number of smaller ones which, in all, will yield 1,000 x $10^6$ kWh per annum. These schemes will be combined with the development of irrigation and navigation on inland waters. Electric power supply, of which 94% is generated in thermal power stations, is gradually taking the form of inter-urban supply fed from major power stations. The existing overload of power stations, due to the constantly rising demand for power will, it is hoped, be elimihated by the construction of a number of large power stations, and by the reorganisation of electric power supply on up-to-date lines.

131 HALDANE, T.G.N. & GOLDING, E.W. *Recent Developments in Large-Scale Wind Power Generation in Great Britain.* Fourth World Power Conference, London. Paper K. 1.

After a brief historical review of wind power in Great Britain, the reasons for the recent consideration of its possibilities as a means of generating electricity on a large scale are given; the high annual energy content of the winds in coastal districts of Scotland, Wales, and South-west England is also pointed out. The establishment of a research committee to study these possibilities is described. The paper discusses the economics of utilizing wind-generated energy in an electricity supply network, and gives estimates of generating costs which might apply to such utilization. The influence of the choice of rated wind speed upon constructional costs and specific outputs at different sites is dealt with, and a practical example is given to emphasize the importance of this choice. Investigations being carried out by the wind power generation committee are described, as are the steps taken to obtain operating experience with pilot plants of 100 kW. capacity. Further developments envisaged, if the present investigations prove them to be justifiable, are outlined. An appendix gives some results already obtained in wind-velocity measurements at favourable sites, and also some estimates of the specific outputs which might be obtained under stated conditions of operation.

132 HARDING, G.R.D.: *Energy Resources and their Development in the Union of South Africa.* Fourth World Power Conference, London. Paper A. 6.

Coal is by far the greatest source of electric power in the Union of South Africa. The country produces no oil or natural gases, and hydro-electric power stations are few and small, as rainfall is seasonal and facilities for economical water-storage are lacking. The paper gives figures showing that while coal is not, as a rule, of high calorific value, it is abundant and, by comparison with many countries, cheap at pithead. The main problem in siting new power stations is not fuel, which is plentiful, but cooling water, which is comparatively scarce. Therefore the spread of industries within the Union is subject to limitations.

Coal has been mined more than 60 years. Figures are given showing the comparative output of the principal mining areas and pithead prices. The paper traces the history of the two great corporations chiefly responsible for the development of power supply in the Union

– the Victoria Falls and Transvaal Power Company, Ltd., and the Electricity Supply Commission – which culminated in the purchase by the Commission of the Company's undertakings in 1948. Some details are given of the Commission's power stations, and also of the principal municipal undertakings, and the paper ends with a summary tabulation of the progress made by the electricity supply industry during the period 1924 to 1947.

133 HARVE, P. & NORDQVIST, B.: *National Resources of Fuels and Water Power in Finland.* Fourth World Power Conference, London. Paper A. 14.

The first part of the report gives some statistical information on the forests of the country, with special regard to firewood production, and also describes the use of wood refuse and peat. The second part, deals with the water-power resources. A short statistical and historical survey is given of the production of, and demand for, electrical energy. The energy supply is based chiefly on the utilization of the water-power resources. The total water-power resources are indicated in Table IX of the report, which contains information on the extent of utilization of water power in 1944 after the armistice, after completion of the present building programme (1951), and after putting into operation the projected additional power plants (1954). The Table also indicates the total amount of water power which it is considered economically justifiable to utilize.

134 HENRIKSEN, R.: *Electric Power Supply in Denmark 1924-49.* Fourth World Power Conference, London. Paper A, 7.

The paper gives a general picture of developments in the production and distribution of electricity in Denmark since 1924. The domestic energy resources in this country are negligible, and the development before 1924 favoured the building of numerous small direct-current works with Diesel engines as prime movers. The increasing consumption of electricity made the unfavourable economic consequences of this development after 1924 more conspicuous, and thereby awoke interest in centralizing the production in fewer plants. The Government realized the importance of this development from a social point of view, and a new Electricity Bill was passed in 1935, under which the Electricity Board was established, with authority to act as adviser for the electricity works in cases of new installations and extensions to existing plants, with the object of furthering a rational development of the production of electricity. The difficulties to be overcome were, however, great.

Inability to import foreign fuel during World War II brought about a radical change in the normal production of power, while after the war the conditions for reorganizing the plants for production and distribution of electricity on more rational lines than before were favourable. All the electricity works able to meet the modern requirements have solved this problem jointly in such a way that the production of electricity, with the exception of a small percentage, will, in two or three years, be taken over by 11 big modern steam power stations.

Works situated near big towns will be built for combined electricity production and heat production for district heating; and finally information is given on the possibility of importing hydro-electric energy from Denmark's neighbouring countries, Sweden and Norway.

135 HOLADAY, W.M.: *Advances in Petroleum Refining.* Fourth World Power Conference, London. Paper C1, 1.

The rapid development of the American petroleum industry during the past 30 years is the result, primarily, of the development and application of the automotive engine. Consequently, the advances in refining have centered about means for producing increased quantities of higher-quality gasolines in

an economical fashion. At present, the industry in the United States has available a variety of processes to maintain a reasonable balance in fuel production to meet the expected variations in volume demand during the next decade. An exception may arise in the case of converting additional residual fuel to more valuable products - particularly in view of increased distribution and utilization of natural gas for industrial heating and power applications. It appears quite certain that trends in fuels utilization will require the development and application of new refining procedures to raise the anti-knock quality of motor gasobines. Possible means to accomplish this and some of the costs are discussed together with the alternative steps which might be taken by motor car manufacturers to utilize more efficiently the anti-knock quality of the gasoline that can be made with currently available facilities.

136 HUBBERT, M. KING : *Energy from Fossil Fuels.* Science, v. 109, 2823/ p. 103-9, 1949.

The author considers the rate of increase and the magnitude of the consumption of energy from fossil fuels. He concludes that our present position is precarious. 'Yet despite this, it will still be physically possible to stabilize the human population at some reasonable figure, and by means of the energy from sunshine alone to utilize low-grade concentrations of materials and still maintain a high-energy industrial civilization.'

137 INDIAN NATIONAL COMMITTEE : *An Assessment of Energy Resources and a Record of Their Development in India.* Fourth World Power Conference, London. Paper A. 12.

The energy resources of India are limited to coal and water power. Workable coal reserves in the Indian Union may be estimated at approximately $15,000 \times 10^6$ tons, of which $3,000 \times 10^6$ tons are at present being worked. The annual coal production in India, during 1948, is about $30 \times 10^6$ tons. Although a comprehensive survey of the water-power resources has not yet been undertaken, it has been estimated that India's ultimate water-power potential may amount to about $25 \times 10^6$ kW. The total capacity of investigated sites is $8.5 \times 10^6$ kW., while the hydro-electric installations already completed amount to only $0.5 \times 10^6$ kW. The Government of India is evincing great interest in rationalizing coal production methods and also in the large-scale development of water-power resources.

138 IRISH NATIONAL COMMITTEE : *The Energy Resources and Power Developments of the Republic of Ireland.* Fourth World Power Conference, London. Paper A. 11.

The energy resources of Ireland, as summarized in this paper, consist of a small amount of coal, a certain limited amount of water power, and a substantial amount of peat. The coal is mostly anthracite, and the workable reserves are about $19 \times 10^6$ tons. The main fuel reserve is in the peat bogs which cover an area of some $3 \times 10^6$ acres. There is also water power available estimated to give a useful output of some $900 \times 10^6$ to $1,200 \times 10^6$ kWh. per annum.

139 JERIC, J.: *Energy Resources and Power Developments.* Fourth World Power Conference London.. A. 13.

The report gives a survey of the state of power resources in Yugoslavia, based on present-day knowledge. It also shows the development of power economics during the period from 1924 to 1948 inclusive, supported by statistics covering the production and consumption of natural fuels, of water power, and of electrical energy.

140 KEYS, DAVID A.: *Atomic Energy Development in Canada.* Fourth World Power Conference, London. Paper J. 4.

The major atomic energy project in Canada, operated by the National Research Council for the Atomic Energy Control Board, is at Chalk River, where there are heavy-water reactors in operation. There are approximately 1,200 employees, about one-third of whom are scientific and technical personnel, and a hundred buildings at the project, including special laboratories for nuclear and technical physics, chemical and chemical engineering research, biological and medical investigations, as well as chemical separation and isotope-production branches. Unique facilities are available for investigations and production of isotopes of high specific activity. There are high-voltage accelerators. A special branch is devoted to investigating and designing future systems for new reactors. The Canadian effort is directed toward the peace-time aspects of atomic energy.

141 KHAN, N.M.: *A Survey of the Coal Resources of Pakistan.* Fourth World Power Conference London. Paper A. 26.

Pakistan came into being in August, 1947. In view of her meagre fuel resources, immediate attention was given to the study of her coal reserves. Due to the availability of better-quality coals from the Gondwana coal fields the Tertiary coals of the Extra Peninsular areas of the Indo-Pakistan Sub-continent have remained neglected. Soft shales and clays of the various epochs of the Eocene Age contain the main deposits of coal. The Tertiary coal seams are characterised by marked physical and chemical variations in different areas. Total workable reserves obtainable in Pakistan are about $104 \times 10^6$ tons. These estimates may be increased considerably if the difficulty in mining below water level is overcome, in the case of Baluchistan, and if improved methods of haulage and mining are introduced in other coal fields.

142 KOWARSKI, L.: *French Developments in Atomic Energy.* Fourth World Power Conference, London. Paper J. 2.

In the years 1947-9, the French Atomic Energy Commission built up the staff of about 600 persons, employed at the provisional atomic research establishment at Chatillon , and built and put into operation a nuclear reactor of a few kilowatts. It is now engaged in a construction programme involving the establishment of a permanent research centre 12-1/2 miles from Paris, the erection of a second atomic pile (about 1,000 kW), and the construction of several large-scale pieces of nuclear research equipment. Success has been achieved in the training of scientific and technical specialists in nucleonics. The possibilities of further atomic progress in France on a widened basis will largely be dependent on the world situation two or three years hence, and on the results achieved under the present programme.

143 KUNTSCHEN, F. & ETIENNE, E.H.: *The Resources and Economic Utilization of Energy in Switzerland since 1924.* Fourth World Power Conference, London. Paper A. 9.

The paper gives a brief review of the power resources of Switzerland, of which only water-power resources and wood fuel play an important economic part. After giving information on hydraulic power and pointing out its importance, the paper outlines the development of resources and of the generation of electric energy during the last quarter of a century. The relative importance of fuel and power requirements for heat production is summarized in a balance sheet of heat sources.

144 LILJEBLAD, R.: *Some Economic and Technical Aspects of the Use of Nuclear Fuel for Power Production.* Fourth World Power Conference, London. Paper J. 5.

The author examines various economic factors involved in the building and use

of atomic power plants, and discusses their significance. He then deals briefly with some of the technical aspects of atomic power production, mentioning the heat exchanger and steam turbine as the most suitable combination for transforming atomic energy into electric power, and touches upon some of the engineering problems that may be encountered in the design of this type of power plant. Some determining factors are also discussed regarding the possibility of breeding in a reactor.

145 MACFARLANE, W.A.: *U N S C C U R* Journal of the Institute of Fuel, v. 23, p. 48-49, 1950.

The author gives a highly condensed review of those aspects of the (1949) United Nations Scientific Conference on the Conservation and Utilisation of Resources which were concerned with fuels and their uses.

146 MALICOPOULOS, S.: *The Water-Power Resources of Greece and their Development.* Fourth World Power Conference, London. Paper A. 5.

The energy resources of Greece are water power and lignites. The water power is sufficient to cover present and future needs. Only a small portion of the water power has been developed. In 1940, of a total capacity of prime movers in the Greek mainland of 336.026 h.p., 50.003 were hydraulic. In 1939, of the 317 electric supply plants in all Greece (with a capacity of 175.397 h.p. and a production of 310.043.225 kWh), 16 were hydraulic, with a capacity of 7,214 h.p. and a production of 22.578.949 kWh.

147 MARSHALL, C.W.: *Other Sources of Energy.* Fourth World Power Conference, London. Paper K. General Report.

The papers in Section K deal with projects for, and achievements in, the development of unusual and difficult sources of power and energy - all special aspects of the solar forms. The author considers wind-power generation in Great Britain, the application of natural steam to the production of electric power, heat pumps in the USA.

148 MATHER, KIRTLEY F.: *Petroleum, Today and Tomorrow.* The Advancement of Science, v. 4, p. 292-300, 1948.

Petroleum output, proved reserves and consumption are compared geographically and on the basis of controlling interest. It is concluded that petroleum reserves are adequate to world needs for 50-75 years, given freedom of distribution. If present trends continue, the United States will be a 'have-not nation' for petroleum 10-20 years from 1947; and the 'have nations' will be the Soviet Union, Kuwait, Iran, Iraq, Arabia and the East Indies. Alternative sources (oil shale and coal) are described as abundant, but a rapid change-over is not to be expected.

149 MENZEL, DONALD H.: *Our Sun.* Blakiston, 1949.

The latest volume in the Harvard Books on Astronomy, a series for non-technical readers based upon original investigations by eminent authorities. Deals not only with solar activity, but also with the relationship between the sun and our natural resources, and the possibilities of using solar energy as a source of heat.

150 MOCH, P. & WAGNER, G.: *Production and Utilization of Natural Gas in France. Fourth World Power Conference,* London. Paper D1. 2.

Natural gas is produced mainly in the south-west of France, where the Saint-Marcet gas field was discovered in 1939 and developed after 1942. The gas is produced from Jurassic dolomites, and the wells have an important open flow capacity. After being treated in the Boussens natural gasoline plant, the gas is distributed to

the consumers through the most important French pipeline system, 500 miles long. The main uses are the following : town gas manufacturing or replacement; furnace and boiler heating; manufacture of fertilizers; motor fuel gas. The use of natural gas already represents a yearly saving of 420,000 tons of coal and 82,000 tons of gasoline, propane, and butane.

151 NETHERLANDS NATIONAL COMMITTEE : *Energy Resources and Power Developments in the Netherlands.* Fourth World Power Conference, London. Paper A. 23.

From 1925 onwards, the consumption of solid, liquid, and gaseous fuels has approximately doubled in The Netherlands. The consumption of electric energy is now about five times that in 1925. The development of the production was seriously hampered by World War II. Production and consumption of coal were in quantitative equilibrium before the war, but now and in the future the consumption will exceed the production. Much has been done to make the production of coal more remunerative. The consumption of brown coal and peat is only of importance in times of lack of fuel. The production of oil in The Netherlands started in 1943 and is estimated to be only a fraction of the consumption. The greater part of the oil consumed is refined in The Netherlands. Petroleum coke, butane gas, and propane gas, obtained from the refining of oil, are also used as fuels. Important concentration has taken place and is still in progress in gasworks and in blast furnaces. It is expected that, in the future, part of The Netherlands will be supplied with natural gas. Important developments have taken place in prime movers from 1925 onwards.

152 NORWEGIAN NATIONAL COMMITTEE : *Energy Resources and Power Developments in Norway.* Fourth World Power Conference, London. Paper A. 8.

Owing to her geographical and topographical conditions, Norway possesses an abundance of water power. The mean rate of downpour is about 47 in. per year, and the average altitude of the country is approximately 1,600 ft. above sea level. Regulation of water-flow is necessary because a large portion of the downpour occurs as snow. Numerous lakes located at high altitudes form natural storage reservoirs, which are easy to regulate without much damage to cultivated areas. The present all-year water-power capacity is about 16% of the total resources supplying about 85% of the population with electricity. Less than 1% of the generated electric energy is produced in thermal power-plants.

The coal layers in the central part of Spitzbergen are estimated at about $1{,}500 \times 10^6$ tons. In 1948 the production in the Norwegian mines was 450,000 tons. A new electric coking process has been worked out, by which it will be possible to produce from the Spitzbergen coals high-reactive coke briquettes, low temperature coal, tar, petrol, and Diesel oil.

In 1942 and 1943 more than $70.6 \times 10^6$ cu.ft. of peat was produced per year. The productive forest area is approximately $7.5 \times 10^6$ hectares. Norway has no liquid fuel resources and no natural gas. It is believed that the country has sufficient raw material for atomic energy for its own future use.

153 OLIPHANT, M.L.: *The Industrial Applications of Atomic Energy.* Journal of the Royal Society of Arts, v. 98, 4819, p. 456-467. 1950.

Existing and possible types of nuclear reactor are reviewed in relation to the 'breeding' of fissile material. The author concludes that the cost will ultimately be able te compete with, and probably much cheaper than, that of power from coal; that the time required to reach this stage of development is unlikely to be less than 10-15 years (but without allowance for the accumulation of fissile material by breeding as in the previous reference); and that

power from hydrogen is only a remote possibility.

154 OSARA, N.A.: *Substitution of Liquid Fuels by Other Materials in Finland during the Second World War.* Fourth World Power Conference, London. Paper C2. 7.

The report deals with the possibilities of safeguarding the supply of motor fuels in Finland in times when imports are restricted. The author considers the following four main ways of achieving this end: production of synthetic oil, production of alcohol, use of wood gas, and storing of imported oil. Experience during the Second World War showed that it is impossible, in a country like Finland, to arrive at a general solution of the question of substituting home-made fuel for the common mineral oils. The production of synthetic oil would involve considerable difficulties, for financial and technical reasons. The production of alcohol cannot be increased arbitrarily, and the storing of oil leads to complications of various kinds. The country thus has to rely mainly on the use of wood and charcoal for satisfying the motor fuel demand when fuel can no longer be imported. The main part of the report deals with the use of wood gas, and contains information on the results and experience obtained with wood and charcoal gas-producers in motor cars.

155 PARKER, A.: *World Energy Resources and their Utilization*. 36th Thomas Hawksley Lecture of the (British) Institution of Mechanical Engineers. Proceedings of the Institution of Mechanical Engineers, v. 160, p. 441-453, 1949.

This is the most recent and comprehensive of British reviews. In its two main divisions, the author considers, first, resources and production (coal, peat, petroleum, oil shale, natural gas, atomic energy, wood, vegetable and animal wastes, non-tidal water power, wind power, terrestrial heat energy, solar energy, food and man-power); and, second, utilization and efficiency. He states that from the analysis presented it might be concluded that the total resources of irreplaceable forms of energy would be sufficient at present rates for many centuries: but (1) these resources have be garnered, harnessed, distributed, and transformed and (2), they are unevenly distributed in relation to requirements, which vary greatly.

156 POLITICAL AND ECONOMIC PLANNING : *The British Fuel and Power Industries.* P.E. P., 1947

The greater part of this volume is a reference book, with content as indicated in the title. After a review of technical considerations affecting use, the report passes to a discussion of the possibilities of tariff co-ordination as a means for securing the best use of the national fuel resources of Great Britain.

157 PORTUGUESE NATIONAL COMMITTEE : *Resources and Development in the Production of Electrical Power.* Fourth World Power Conference, London. Paper A. 4.

Portugal is not endowed with large power reserves but, nevertheless, it still offers possibilities for substantial increases in electrical power derived from hydraulic sources. With the promulgation, in 1944, of the Law of National Electrification laying down the conditions for generation, transmission, and distribution of electrical energy in the country, and owing to the direct financial participation of the State in the constitution of the new undertakings, a fresh impetus was given to the development of water power. It is reasonable to foresee a production exceeding $1.000 \times 10^6$ kWh in 1952. Although this will represent little more than one-eighthof the total that can be economically harnessed, it corresponds to an increase of six times the country's possibilities before World War II.

158 PRYCE, M.H.L.: *Atomic Power: What Are the Prospects.* Discovery, v. 9, 3, p. 78-82, 1948.

The author considers that nuclear energy will be mainly used in highly centralized generating plants. Assuming that the 'breeding' of fissile material is feasible, he estimates that between 7 and 700 years world energy requirements might be met from uranium, and that the exhaustion of thorium supplies seems remote. Ignoring possible diversions, it is concluded that it would take 30 years to develop atomic energy to the stage when it could effectively replace other sources of power.

159 ROTHMAN, S.C. (ed.): *Constructive Uses of Atomic Energy.* Harper & Brothers, 1949.

Articles collected from a mass of literature to "dispel the common misconception that atomic energy is beyond the comprehension of the layman." Arthur Compton writes on "Atomic Energy as a Human Asset," and Samuel K. Allison on "Atomic Energy in Industry and the Physical Sciences". There are essays on atomic energy in metallurgical research, for aircraft engines, and on the impact of nucleonics on ceramics. There is a full bibliography.

160 ROWSE, R.H.: *Progress Review No 3: Domestic Heating.* Journal of the Institute of Fuel, v. 23, p. 32-34, 1950.

Gives a general review of British developments in domestic heating. Mention is made of a series of experiments which is being carried out in a group of 20 experimental houses on the (British) Building Research Stations experimental housing estate at Abbots Langley.

161 RUHEMANN, MARTIN : *Power.* Sigma (Introduction to Science series), 1946.

A lively little book which explains the significance of power for our civilization and describes the ways in which it is produced and utilized. The basic physical concepts are introduced and explained in terms of easily understood examples.

162 RUISS, von, O. & VAS, O. : *Energy Resources and Power Developments in Austria.* Fourth World Power Conference, London. Paper A. 24.

Austria's workable coal resources are estimated at $200 \times 10^6$ tons, comprising 1% coal, 10% high-quality coal, and 89% minor-quality brown coal. The output of the home production can only satisfy the country's requirements to the extent of one-third; the remainder must be supplied by imports, principally in the form of coal. In twenty towns the total coal consumption of the gasworks accounts for about one-sixth of Austria's coal imports. Five-sixths of the gas production is carried out at the gasworks of Vienna. For six years, natural gas from the oil fields near Vienna has been added to the Viennese town gas. Austria's largest energy resources are its water power. At present, about $40 \times 10^9$ kWh (annual output) are worth developing, of which approximately one-eighth is already being utilized. Thus ample raw hydro-electric power is available for further development - production in excess of national requirements may be expected in the future - which can be utilized within the framework of an all-European cooperation. The Alpine water-power resources in Western Austria have been developed first, in consequence of favourable geographical circumstances, although the principal area of consumption is in the densely populated and industrialized eastern part of the country.

Some of the more efficient steam plants are located near the consumer, while some are near the mines. Thus there are steam power stations in Vienna and Linz as well as in places with larger industrial plants and in the vicinity of larger brown coal mines. In some of these power stations brown coal of inferior quality is being used with the aid of special apparatus.

Austria's significant findings of oil and natural gas might enable a wider use to be made of this fuel for the production of power than has hitherto been the case. The interconnexions which formerly existed between the coal fields (e.g. Upper Silesia and Ruhr) to-day are outside Austrian territory, a fact which has led to the erection of power plants using coal. At present these plants are dependent on imported coal since the boilers for the heating installations have not been adapted to the use of home fuels. The bulk of the Austrian power supply is produced by power plants belonging to Public Syndicates of Supply. Energy is transmitted between the production centre, located in the more westerly part of Austria, and the main consumption regions in the east of the country, by a 110kV network. A 220kV high-tension line is about to be completed. For economy, the electrical power produced in Vorarlberg and partly in the Tyrol is not delivered to the Austrian national network but is made available for export to Germany. In exchange for these exports Austria receives corresponding supplies of winter power. Of the power production of the country more than one-half is absorbed by large industrial consumers; about one-fifth by small consumers (domestic, trade, and agriculture); traffic absorbs approximately one-tenth; and almost one-sixth is lost by long-distance transmission.

163 SALMON, P.: *General Report on the Energy Resources of France and the French Union - Historical Record of the Development of these Resources since 1924.* Fourth World Power Conference, London. Paper A. 10.

The resources of power in France are of average importance, and on the same scale as those of other European countries. The present situation, as based on the statistics for the year 1948, may be summed up as follows : Out of about 65 x $10^6$ tons of coal which France needs annually for her economy, she produces some 45%; the rest she imports. All the resources of electrical power are national, and the quantity of electricity produced thermally is about equal to that of hydraulic origin, the total actual needs being about 28 x $10^9$ kWh. per year.

Apart from her participation in the production of Irakian oil, France does not really possess any oil fields. She has, however, an important refinery industry, which continues to develop, and enables her to treat about 12 x $10^6$ tons of crude oil per year. Her resources in natural gases are not great (about 6,360 x $10^6$ cu. ft. per year). Wood and spirit (alcohol) considered as sources of power are merely substitute fuels and are of little importance. The marine heat pump, tidal plants with their privileged situation on the French coasts, and wind power, are the object of very advanced studies, although the stage of wide pratical application has not yet been reached. Finally, experiments on nuclear energy are being carried out with the atomic pile at Châtillon.

The sources of power in the French Union reach a very high level, though very few are at present being exploited. An important hydro-electric potential is to be found in nearly every country of the French Union. Coal seams are limited to Tonkin, Morocco, and Madagascar, and the oil industry is only at the prospecting stage. The development of power resources in France has determined the industrial and economic life of the country. From 1924 to our own days, there has been a general increase in coal, electricity and oil.

164 SCHROEDER, W.C. & FIELDNER, A.C.: *Synthetic Liquid Fuels.* Fourth World Power Conference, London. Paper C2. 1.

Work on synthetic liquid fuels in the United States, both by the government and industry, is of considerable magnitude, but the problem of meeting increased oil requirements is being thrust upon the country at a much faster rate than was anticipated in 1944 and 1945, when the present programs were planned. Fortunately, due largely to process improvements, the cost factors upon which any large-scale

synthetic fuel production will depend are becoming increasingly favorable in the United States. However, the improved relative cost position of the synthetic products also is attributable in part to sharply increasing costs of finding and developing new petroleum. If these trends continue, it is probable that a large synthetic fuel industry based on coal and oil shale will develop in the United States. Known reserves of raw materials are so great that they can meet the country's needs for a long time. But it is well to remember that much remains to be done, not only in pilot-plant research and development but in plant construction as well, before liquid products are available in quantity from coal and oil shale.

165 SCIENTIFIC WORKERS, ASSOCIATION OF : *Report on Petroleum.* London, 1950

A pamphlet on the world petroleum situation prepared by a sub-committee of members of the A.Sc.W. who are connected with the petroleum industry. The section headings are: world survey, origin of petroleum, exploration, drilling and production, transport and storage; nature of petroleum, distillation, products of distillation, cracking; gas, motor spirit, kerosene, gas oil, lubricating oil, fuel oil, other products; and a petroleum policy for Britain. There is a useful bibliography of reports, books and papers.

166 SIMON, F.E.: *Power Sources and Power Utilisation.* Proceedings of the Royal Institution, v. 34, 2, No. 155, p. 266-286, 1949.

The author considers that more efficient utilisation of energy offers a quicker solution to power shortages than does the exploitation of new sources. A comparable effort to that devoted to new sources should be given to the improvement of technical and social conditions in coal mining, including underground gasification. When conventional fuel supplies approach exhaustion, as much effort should be put into the exploitation of solar energy as atomic.

167 SIMON, F.E.: *The World Power Situation.* Discovery, v. 10, p. 88-92, 1949.

This is an article based on the lecture printed as the previous reference.

168 SLEBINGER, VLADIMIR : *Statistics of All Existing Water-Power Resources.* Fourth World Power Conference, London. Paper H1. 9.

"The Statistical Year-Book of the World Power Conference" gives, in Table 17, statistics of all water-power resources which are capable of being developed. However, the definition "faculty of development" is subject to changes, and every country has a different opinion of the possibilities of the development of its water-power resources. Therefore, in order to obtain comparable and unbiased statistics relating to water power, it is necessary to tabulate all existing natural sources of water power. The classification of these water-power sources into those capable and those not capable of development, is a subject for special study. The method for determining all the water power theoretically available is simple, as it assumes only a knowledge of the arithmetical mean flow and of the head, from the source to the lowest stream level. The suggestion is made that, in addition to column 4 in Table 17 of the "Statistical Year-Book", figures for "gross power capable of being developed" should be included, as well as statistics relating to gross power theoretically available. The present paper includes a newly compiled table giving all potential water power sources in the world. The total amount is $5{,}609 \times 10^6$ kW., with an accuracy of $\pm 15\%$. In conclusion, it is pointed out that the existing natural water resources considerably exceed the present estimates, and that large concentrations of hydro-electric power exist in various regions, most of which

are rather remote from the consumers and from centres of economic importance. There is good reason to believe that these large sources will be utilized, bringing about a considerable expansion of the economies of various countries, and a closer co-operation between nations.

169 SMITH, D.M.: *Land Type Gas Turbines.* Fourth World Power Conference, London. Paper G. 3.

In Great Britain no land type gas turbines are yet in commercial service, but experimental gas turbines are running in manufacturers' works and other gas turbines are in construction. Gas turbines are at present being offered on commercial terms only for burning liquid or gaseous fuel, and this limits their economic application for land power service in Great Britain to plants of low load-factor and to certain other special cases. Advances in cycle conditions will lead in the course of time to gas turbine plants giving higher thermal efficiency than can be offered at present, but such advances are likely to be slow for industrial land power plants. Much attention is being directed to the possibilities of coal-burning gas turbines. External combustion schemes, internal combustion schemes burning pulverised coal, and internal combustion schemes burning products of gasification are all under consideration. Considerable development will be required to bring any of these schemes to commercial success. The main prospective application of such plants appears to be in the moderate power range. Gas-steam cycles, with coal-fired boilers pressurized by the gas turbine plant, offer a promising field for application of gas turbines to large-scale base-load generating plants.

170 SMITH, GEORGE H.: *Transportation, Storage, and Peak Load Supply of Natural Gas.* Fourth World Power Conference, London. Paper D1. 1.

Natural gas now supplies 13.3% of the natural basic fuel in the U.S.A. and is constantly growing in importance to residential, industrial and commercial customers and for chemical reformation. In 1947, the inter-state movement of natural gas was 45% of the gas sold by pipelines to gas utility companies. For many industrial purposes it is a "premium" fuel. Its value far exceeds the value of its heat content because of simplifications made possible by its use. For these uses it cannot be replaced readily by another form of fuel. Natural gas pipelines now comprise a network of 251,000 miles, which is greater than the mileage of main-line railroad tracks. Natural gas was first produced in the U.S. as a waste product in the exploration for, and production of, petroleum. To some, this waste was the incentive to build pipe lines.

Pipe lines must have high load factors, one method of achieving which is by selling interruptible loads for summer consumption. Pipe line design has made great advances since 1920, the beginning of long-distance gas transportation. In 1926, there was developed the large-diameter thin-walled pipe, which carried more gas at high pressure with less steel. To-day, 26, 30, and 32 in. pipe is being used and, or alternatively, planned for use. Large-diameter thin-walled pipe brought problems of welding and bending. To-day a cold-head machine is available to eliminate wrinkle bending, which is thought to weaken the pipe structure. The future will see higher yield strength steel with the same chemical characteristics as the pipe to-day. Gas stored in depleted gas or oil wells can be so stored for from 2 to 53 cents per thousand cubic feet. To-day there are over 80 fields in use, with a capacity of $440 \times 10^9$ standard cu-ft. of gas, and 14 fields are being prepared for use, adding $56 \times 10^9$ cu. ft. of storage space. Peak loads are met in the United States by using gas in storage, cutting interruptible loads for as long as necessary, rebuilding water gas sets for oil-gas manufacture, and by selecting as customers industries with seasonal loads.

171 SPORN, PHILIP & OTHERS : *Heat Pump Progress in the United States.* Fourth World Power Conference, London. Paper K.4.

The heat pump is receiving increasing attention from many interested sources. Much time, effort, and money, have been and are being expended to bring the device to that state of perfection needed for large-scale acceptance of the equipment. The merits of the heat pump for (1) all-year-round comfort heating and cooling; (2) the supply of domestic hot water; and (3) the industrial application process for drying, evaporation, and distillation, are increasingly recognized. An appraisal of the overall situation at this time in the U.S.A. is most encouraging in its prospects for the future.

172 SUMNER, J.A.: *The Norwich Heat Pump.* Proceedings of the Institution of Mechanical Engineers, v. 158, p. 22-29, 1948.

An experiment is described in the use of a 'heat pump' to provide heating for an office building with a cubic content of 500,000 cu. ft. Figures are given. The saving in energy is estimated at about 50 per cent, and in cost at 6.4 per cent, or 26 per cent, according to the conditions of operation after allowance is made for capital charges and depreciation.

173 TELKES, MARIA : *Space Heating with Solar Energy.* The Scientific Monthly, v. 69, 6, p. 394-7, 1949.

Space heating consumes nearly 30 per cent of the fuel used in the U.S.A. This percentage is greater in other parts of the world. Scarcity of fuel depresses the standard of living, and availability of fuel is one of the most important factors in the progress of civilization. Is it necessary to rely on fossil fuel alone? Can we capture and store solar energy and use it to replace fossil fuel? Description of U.S.A. experiments in domestic heating by solar energy. Considerable research and development work are needed. The potentialities are great, with important social and economic implications.

174 THE TIMES (London): *Power From Brazilian Hills.* 21 September, 1949

Brazil has resources which place it sixth in hydro-electric potential among the countries of the world. Only a tenth of their energy is uded. Details are given of the significance of industrial expansion based on hydro-electricity.

175 TIBERGHIEN, E.: *Energy Resources and the Production of Power in Belgium.* Fourth World Power Conference, London. Paper A. 19.

The Belgian National Report gives a survey of the Belgian resources in the field of electric power production. Nearly the whole electricity supply, which amounted to $8.2 \times 10^9$ kWh in 1949, is of thermal origin, of which about 85% is derived from coal, and about 15% from blast-furnace gas. The hydro-electric resources are only sufficient to produce a small part of the electric supply, and the use of fuel-oil is at present limited to a few plants of low power. The report gives an analysis of the methods of production, classified according to the date at which they were put into operation and by the technical characteristics of the units. In conclusion a survey is given of the schedules of the new plant now under erection, amounting to more than 1,100 MW, which are planned for the years 1950-3

176 UNGARO, MARIO : *Development and Utilization of the Energy Resources of Italy.* Fourth World Power Conference, London. Paper A. 22.

The paper shows the extent to which the energy resources of Italy contributed towards the requirements of the country during the period 1938-48. These sources of energy may be divided into :- solid fuels; liquid and gaseous fuels; electric

power of hydraulic and geothermic origin. Estimates are given of the reserves of these three sources of energy, together with an account of their development during previous years, and the developments which are foreshadowed for the future. Current investigations of the sub-soil of Italy concerning liquid and gaseous fuels are discussed, with anticipated results of such investigations. Statistics are given of available hydraulic resources which might be used to advantage from the economic point of view, and the methods followed in order to make the maximum possible use of the hydraulic resources are described. Information is given on the resources of geothermal electric energy, and forecasts made for the future utilization of this source of energy. The reasons are given why the development of thermo-electric generating stations is necessary, in order to make full use of the hydraulic resources and to meet the future demands of the country on electric energy. Finally, statistics of the availability of national and imported sources of energy are given for the years 1924 - 48.

177 UNITED KINGDOM : MINISTRY OF FUEL AND POWER : *Energy Resources and Power Development in the United Kingdom.* Fourth World Power Conference, London. Paper A. 20.

The fuel and power resources of the United Kingdom are surveyed. Coal reserves are adequate at present consumption rates for at least 100 and probably 200 years, but those of lignite, peat, oil shale, petroleum, and natural gas are small in comparison. Water-power resources in Scotland are substantial, and are undergoing rapid development, but coal-fired stations will continue to provide 90% of the energy requirements of the United Kingdom. Should it prove worth while to exploit wind and tidal power, the United Kingdom will be well situated. Considerable attention is being paid to the development of the former. Developments in prime movers in the United Kingdom during the last 25 years are examined. Progress with the gas turbine has been particularly rapid, and this prime mover is now finding industrial application. Steam turbine progress, though rapid up to the Second World War, has since tended to lag.

178 UPMARK, E.& BLOMQVIST, E.: *Sweden: Energy Resources and Power Development since 1924.* Fourth World Power Conference, London. Paper A. 16.

Figures are given relating to energy resources and power development in Sweden since 1924. Coal and coke are mainly imported. During the Second World War, the production of wood fuel and peat increased considerably; production now stands at about the pre-war level. The liquid fuels required are mainly imported; the refinery capacity has been considerably increased, as has also the use of fuel and Diesel oil. There are no resources of natural gas. The water-power resources are most important, most electricity being generated by water-power plants; on an **average, only 7% is produced by steam power plants. About one-third of the usable water power has so far been developed; a considerable construction programme now in progress will bring the figure to 40% within a few years.**

179 U.S. DEPARTMENT OF STATE: *Energy Resources of the World.* U.S. Government Printing Office. Publication 3428. Released June 1949.

The Preface reads: 'This study of the energy resources of the world is an outgrowth of studies initiated in the Department of State in 1942, designed to bring together certain background data needed in the formulation of U.S. foreign policy. The study is primarily a compilation of data on the energy resources of the world; their occurrence, production, processing, trade, and utilization. It includes occasional observations on various economic factors to which energy resources may be related, but does not undertake detailed analysis of these relationships.

Such analysis would call for additional information and careful examination of many different factors - geographic, historic and economic - and is thus beyond the scope of the present study.

"The emphasis throughout the study is on the fundamental unity of the energy sources. For although each source of energy has, under particular circumstances, certain advantages of form, utility or accessibility, specific needs for energy can be satisfied to a considerable extent by the substitution of one source for another or the conversion of one form to another. Coal, for example, or oil, or gas or hydroelectric power can be used, directly or indirectly, to provide light, to provide power to drive machines, or to provide heat for domestic or industrial purposes.

"This concept of the fundamental unity of all energy sources is basic to any real understanding of energy and its implications. Hence, while much of this study is devoted to particular sources of energy, discussions of the separate sources have been subordinated to a main thesis of their unity.

"The approach is largely geographic. Comparisons are made of conditions in the several countries as of a given year, 1937 for the most part, without any detailed examination of historical changes in energy resource patterns.

"The present study, prepared under the direction of Nathaniel B. Guyol, was issued in provisional form in 1945 to a number of persons officially or technically concerned with energy resources. It is now being reissued in revised form for public use in response to the growing interest in the energy resources of the world."

180 VIRGILI, ENEA : *The Application of Natural Steam to the Production of Electric Power* Fourth World Power Conference, London. Paper K. 2.

This report deals with the use of natural steam for the production of electric energy, in the district of Larderello (Tuscany, Italy). This is the most important application of terrestrial heat in existence, and since 1949 has been producing more than 1,000 x $10^6$ kWh per annum. Consideration is given to the origin of natural steam, followed by a description of the difficulties encountered in prospecting for steam, and of the technique of well drilling. Chemical and physical properties of the steam are set out, together with diagrams of its application to electric power plants. Brief consideration is given to certain problems which have still to be solved in this particular branch of engineering.

181 WARD, EDWARD: *District Heating.* Discovery, v. 10, 9, p. 282-288, 1949

The author reviews available data on district heating, largely from American sources, and concludes that district heating is a practical proposition for widespread application in Great Britain, especially sohemes working from power stations. The tendency is regretted to regard district heating purely in relation to domestic heating standards: it should be considered as an integral part of national schemes of reconstruction and in relation to the fuel and power situation.

182 WRATHER & others: *Energy Resources of the United States.* Fourth World Power Conference London. Paper A. 1.

Coal continues to be the greatest single source of energy in the U.S.A. New surveys now under way may indicate that the assured, immediately accessible reserve of recoverable coal represents only a fraction of the estimated total in the ground. The rate of production of coal has not shown a rising trend in the U.S.A. because of (1) improvements in the efficiency of use, and (2) competition of liquid and gaseous fuels. Marked progress is being made in the technology of mining. The trend is toward lower mining costs, yet also toward somewhat lower recovery.

The U.S.A. is committing itself to a

liquid- and gaseous-fuel economy. In two decades petroleum production increased over twofold, and natural-gas production over threefold. Oil and gas now supply nearly half of the nation's energy requirement. The estimates of "proved reserves" of oil and gas have continued to increase each year, so that a fairly level trend in the ratio of proved reserves to annual production has been maintained. Natural gas now supplies more than one-tenth of the energy consumed. In recent years the pipe-line distribution of natural gas has shown a phenomenal growth.

Known reserves of oil that can be produced from oil shale are four or five times the proved reserves of petroleum recoverable by present methods, but as yet no estimate has been made of the quantity of shale oil that can be recovered at costs approaching the costs of petroleum.

Present estimates of the power potential of the rivers of the United States are more than double the estimates made 20 years ago, because of the recognition of the advantages of multiple-purpose dam and reservoir projects for irrigation, flood control, navigation, and power. Only about 16% of the estimated potential water power of the nation is now being used.

The only other substantial source of energy is vegetation, which supplies about 6% of the total. Wind power and tidal power have not been developed industrially. The direct use of solar radiation for the heating of buildings is receiving some attention. The use of atomic fission for industrial power is a project for the future, and its technical and economic potentialities are not yet clear.

# FILMS ON ENERGY

The films here listed, alphabetically by title, are 16 mm., black and white, sound, English narration and titles, unless otherwise stated. The bracketed date is that of their production.

The source from which films can be obtained is indicated in each entry by a symbol. For explanation of symbols and further information about sources, refer to the alphabetical list *Sources* on page 94

All television rights are reserved.

183 ATOMIC, ENERGY (1945-7). 11 min. EBF
Version exists in German.

Animated drawings used to explain basic concepts. Parts and structure of atom. Electronic energy contrasted with nuclear energy. Natural radioactivity, nuclear synthesis, nuclear fission. Atomic energy from sun, chemical energy stored, photosynthesis and combustion.

184 ATOMIC PHYSICS (1948). 90 min., also 35 mm. Versions exist in French, GBI Colombian Spanish, Gastilian Spanish, Danish and Arabic.

This film is intended primarily for scientific instructional purposes, but the sociological implications are clear. The film is in five parts, which can if desired be shown separately for classroom use: (1) History of the atomic theory; (2) rays from atoms - cathode rays, positive rays and X-rays, and the work of Sir J.J. Thomson; (3) nuclear structure of the atom; (4) atom smashing and the discovery of the neutron; (5) uranium fission and the release of atomic energy. Professor Einstein appears in the film and discusses possible peaceful uses of atomic energy. The exposition throughout relies largely on animated diagrams; much of the presentation is at a high technical level.

185 ATOMIC POWER (1947). 19 min. MTFF

The story of the atomic bomb, from 1905 when Einstein defined the relation between matter and energy, re-enacted with Fermi, Einstein, Conant, Oppenheimer and others recreating on the screen the secret roles they played during the war. The processes that led to the atomic age are depicted; how the same men are now playing a determined role in establishing that the force they liberated shall be utilized for the good of mankind.

186 BRIGHT PATH (1940) 35 mins. HPCO

Documentary account of the hydro-electric developments in the Province of Ontario, Canada. Compares flood scenes to scenes of controlled water power. The work of the men engaged in the manufacturing of electricity is high-lighted with construction and operation scenes. Transmission system is explained and developments far in the wilderness are pictured, also some phases of plant maintenance, and the value of electricity in daily life.

187 COLUMBIA: AMERICA'S GREATEST POWER STREAM (1949). 20 min. USDI

Integrated development of the Columbia River for all of its potential values: navigation, flood control, reclamation, recreation, hydro-electric power. Projected program for harnessing 30 million kilowatts of hydroelectric energy on a river system less than 1/10th developed. Use of water power to extend industrial and agricultural opportunity for the residents of and migrants into America's fastest growing region.

188 CORNISH ENGINE . (1948). 35 min., also 35 mm. SFU

Describes itself as "A Chapter in the History of Steam Power." This is a scholarly historical film record of the development of the use of steam for pumping water out of mines in the nineteenth century. A typical Cornish engine is examined and its working principles explained. The photography is of outstanding quality.

189 DIESEL - THE MODERN POWER (1947). 15 min. GM

The fundamental principles of the Diesel engine. The operations of this form of power. Its many uses in power houses, streamlined trains, dutiful switching engines, boats, and other varied uses.

190 DISTRIBUTING HEAT ENERGY (1947-8). 11 min. Versions exist in Afrikaans, Portuguese and Spanish. EBF

Fuel, heating systems, principles underlying heat distribution. Coal, petroleum, natural gas, wood, mechanical energy of falling water. How coal, oil and gas furnaces work; how homes are heated by hot air, hot water, steam. Convection, conduction, radiation.

191 ELEMENT IN HARNESS (1945). 9 min. CSF

Construction of river dams. Harnessing the element of water as a source of hydro-electric power.

192 ENERGY AND ITS TRANSFORMATIONS (1952-3). 11 min. EBF
Versions exist in Afrikaans, Portuguese and Spanish.

Potential, kinetic, radiant energy defined as manifested and used in mechanical, electrical, chemical, thermal forms. Joule's experiment illustrating conservation of energy; present and future sources of energy portrayed.

193 ENERGY FROM SUNLIGHT (1930). 15 min., silent. EPF

Explains the principle of a solar engine. Shows how energy from sunlight stimulates plant growth and is stored for future use in the form of wood and coal.

194 FLOW OF ELECTRICITY (1946). 10 min. YAF

Elementary science film built around inquiries of a boy and girl: factors which affect flow of electricity through a simple electrical circuit; electron theory introduced; simple circuit in home situation.

195 FUELS AND HEAT (1937-8). 11 min. EBF
Versions exist in Afrikaans, Portuguese and Spanish.

Heat energy in terms of source, storage in form of fuel; practical utilization. Manufacture and storage of carbohydrates in plants; role of carbon in burning of fuels; formation of coal and petroleum; process of combustion, molecular action in relation to heat and temperature. Steam and gasoline engines.

196 GATES OF POWER. (1948). 15 min. BCOI

By describing some of the Hydro-Electric projects in the British Isles, the film shows just how power is harnessed, the equipment needed, and explains some of the difficulties which have to be overcome. New dams are seen under construction. In the British Isles the power stations are connected to the grid system that covers the whole country, and the final sequence of the film shows what happens when they are called upon to supply extra current.

197 GENISSIAT (1937-1948). 30 min. AF

This is a record of the building of the great dam in the Rhone Valley, Genissiat, by the Compagnie Nationale du Rhone. The dam is the largest in Europe outside the Dnieprostroi and the film describes its vital importance to the French economy. Includes some interesting animations of the planning and construction of the dam.

198 HARNESSING THE HILLS (1949) 20 mins. COI

This film is the story of the Hydro-Electric scheme in Scotland.

199 HEATING RESEARCH FOR HOUSES (1948). 27 min., also 35 mm. CFU

An account of research being carried out by the Building Research Station (Department of Scientific and Industrial Research) on the best methods of domestic heating. The film is interesting and clear and

affords a valuable illustration of the methods of scientific research in relation to everyday problems.

200 HOOVER DAM (1949). 50 min. USDS

Description of the conditions in the southwestern states that led to construction of Hoover Dam and brief pictorial description of its construction; shows benefits resulting from the dam to irrigation and industries in Southern California.

201 HOW WE GET OUR POWER (1947-9). 10 min. YAF

How all power comes from nature: wind, water, fuels, explosives, the atom.

202 INDUSTRIAL REVOLUTION (1941-2). 11 min. Versions exist in Portuguese and Spanish. EBF

Industrial progress of last 200 years contrasted with slow advance during preceding centuries. Economic, social, cultural improvement of people retarded by necessity for hand labor and existence of only crude, clumsy, machines. Contribution of labor-saving devices to rising standard of living. Mass production techniques, rapid communication, fast transportation.

203 INSIDE THE ATOM (1949) 10 min. NFBC

Atomic power research at Chalk River, Ontario. Peace-time uses for atomic energy.

204 INVISIBLE POWER (1944). IFI

Development of hydro-electricity in the Punjab, how the rivers running down the snowy slopes of the Himalayas have been harnessed to produce power. Industrial progress in India depends to some extent on the rapidity with which electric power is made available and the film is an indication of what can be achieved in other parts of the country.

205 MATTER AND ENERGY (1946-7). 10 min., also color. Coronet

Matter defined; its general properties; its forms, their characteristics. Elements. Compounds. Physical and chemical changes. Matter in motion : energy, mechanical, electrical, chemical, radiant; potential and kinetic. The law of conservation. Conversion of matter into energy.

206 MIRACLE OF HYDRO. 20 min. USDI

The building and benefits in terms of power and flood control of the Bonneville and Grand Coulee Dams on the Columbia River.

207 MIRACLE MAKERS (1941). 10 min. Rental only. TFC - Warner
Educational use in USA only.

Development of water, steam, and electric power; the cyclotron at the University of California. Potential importance of atom as future source of power.

208 NATURE OF ENERGY. (1949). 10 min., also color. Coronet

Scientific concept of energy clarified; relationships of atomic energy to other forms of energy; data basic to understanding scientific advancements and specialized units of electricity, sound, light and heat.

209 NEW WAYS TO DO MORE WITH FARM POWER (1945). 18 min. colour. SOCI

New type of farm power equipment which helps get the job done faster and with less help. Stresses greater use of labour-saving devices.

210 NEW WORLDS FOR OLD (1939). 50 min. BCGA

New applications of gas in industry and the home.

211 ONE WORLD OR NONE (1945-6). 9 min., also 35 mm. FPI

No basic atomic facts are secret because of international development of nuclear physics; why peoples of world must cooperate to control atomic energy.

212 PETROLEUM (1946-7). 11 min. EBF
Version exists in German.

Role of petroleum in today's economic and political life; oil as fuel. Exploration by seismograph to locate oil deposits; drilling, refining. Where world's petroleum resources are located.

213 POWER AND THE LAND (1940). 39 min., also 35 mm. USDA

This film deals with the rural electrification program and shows how through cooperatives farmers can organize and obtain at cost electric power furnished by the government. Typical farm conditions are shown both before and after electrification; the amount of time, energy and convenience that comes with modern equipment is well illustrated.

214 POWER BEHIND THE NATION (1940). 38 min. NWRC

The story of bituminous coal production, transportation, uses and importance in the economic life of the United States.

215 POWER FOR THE HIGHLANDS 15 min. COI

The North of Scotland Hydro-Electricity Board has been set up by Parliament to convert water of the Highlands into power and to promote developments in the Highlands. Explanation of what has been achieved by similar schemes under the T.C.A. Film was taken in Glen Affric, Strathfarrarm Duckie and Galloway.

216 POWER VALLEY (1946). 16 min. NFBC

Shows the development of the resources of the St.Maurice River Valley through electricity.

217 PRODUCTIVITY - KEY TO PLENTY (1948-9). 21 min. EBF

How machines have contributed to improved standards of living during the past century by increasing man's ability to produce. Prosperity dependent on technological progress, on full use of basic sources of power and on wise use of resources. Effect on life of people today.

218 ROMANCE OF A RIVER 20 min. HPCO

A unique engineering achievement carried out in the wilds of nothern Canada. The project diverts a portion of the flow of the Ogoki River from James Bay and Arctic Ocean to the Great Lakes watershed. Also shows the development of a series of power dams.

219 STORY OF ALFRED NOBEL (1939) (Passing Parade Series) TFC-MGM
11 min. Rental for educational use only.

A portrayal of Nobel's research which led to the invention of dynamite, and the events which influenced him to establish the Nobel Prize awards for contributions to world peace.

220 STORY OF COAL (1939). 11 min. KB

How coal is formed; where found; how mined; importance of coal.

221 STORY OF ELECTRICITY (1941). 11 min. KB

Story, dealing with persons and events leading up to present day development of electricity; early discovery of magnetism; how this led to understanding of various other manifestations; Edison's invention of incandescent lamp, etc.

222 TENNESSEE VALLEY AUTHORITY (1941). 20 min. TVA

TVA: Work and accomplishments. Multi-purpose dams help control floods, aid navigation, and produce power. Four dams under construction; agricultural work, rural electrification, research and reforestation.

223 THERMODYNAMICS (1937-8). 11 min. EBF
Versions exist in Portuguese and Spanish.

Concepts that molecular action is affected by heat; that heat is energy; that heat energy can do work, illustrated in heat engines. Energy transformation in steam engine, steam turbine, gasoline engine, Diesel engine. First and second laws of thermodynamics.

224 TRANSFER OF POWER (1937). 22 min., also 35 mm. SFU

The history of the toothed wheel is traced from the wooden cogwheels of wind- and water-mills to modern gears in motor cars, turbines and heavy industry; the film shows the place in this story of iron and steam, steel and oil. Good use is made of animated diagrams to show the origin of the gear-wheel in the lever principle, and the derivation of various shapes of gear-teeth.

225 WATER POWER (1 reel) GBI

This film illustrates modern methods of utilising water power to generate electricity. A typical power scheme in the Grampian Mountains is taken as an example, and is used to show the damming of a loch, the generating station, the distribution of the current and its use in towns for domestic and commercial purposes. Animated diagrams explain the relation of the different parts, importance of the head of water, and working of an hydraulic turbine. A classroom film.

226 WATER POWER (1936-7). 11 min. EBF
Versions exist in Afrikaans, Portuguese and Spanish.

Introducing concept of water as power source; how harnessed. Development of water power in U.S.A. from colonial mills to giant modern hydroelectric plants. Transformation of potential energy into kinetic energy shown in animated drawings. Survey of world potential water power.

227 WHITE ENERGY 20 and 35 min. versions CD

An exposition of the sources of hydro-power in Switzerland including a brief history of the discovery of electric power in the development of the dynamo. Describes the building of dams and impounding of waters in Swiss mountain valleys to produce hydro-power for electric plants. Diagrams and animation are used throughout.

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# THE IDEAL OF AN OPEN WORLD

## OPEN LETTER TO THE UNITED NATIONS

### BY NIELS BOHR

I address myself to the organization, founded for the purpose to further co-operation between nations on all problems of common concern, with some considerations regarding the adjustment of international relations required by modern development of science and technology. At the same time as this development holds out such great promises for the improvement of human welfare it has, in placing formidable means of destruction in the hands of man, presented our whole civilization with a most serious challenge.

My association with the American-British atomic energy project during the war gave me the opportunity of submitting to the governments concerned views regarding the hopes and the dangers which the accomplishment of the project might imply as to the mutual relations between nations. While possibilities still existed of immediate results of the negotiations within the United Nations on an arrangement of the use of atomic energy guaranteeing common security, I have been reluctant in taking part in the public debate on this question. In the present critical situation, however, I have felt that an account of my views and experiences may perhaps contribute to renewed discussion about these matters so deeply influencing international relationship.

In presenting here views which on an early stage impressed themselves on a scientist who had the opportunity to follow developments on close hand I am acting entirely on my own responsibility and without consultation with the government of any country. The aim of the present account and considerations is to point to the unique opportunities for furthering understanding and co-operation between nations which have been created by the revolution of human resources brought about by the advance of science, and to stress that despite previous disappointments these opportunities still remain and that all hopes and all efforts must be centered on their realization.

For the modern rapid development of science and in particular for the adventurous exploration of the properties and structure of the atom, international co-operation of an unprecedented extension and intensity has been of decisive importance. The fruitfulness of the exchange of experiences and ideas between scientists from all parts of the world was a great source of encouragement to every participant and strengthened the hope that an ever closer contact between nations would enable them to work together on the progress of civilization in all its aspects.

Yet, no one confronted with the divergent cultural traditions and social organization of the various countries could fail to be deeply impressed by the difficulties in finding a common approach to many human problems. The growing tension preceding the second world war accentuated these difficulties and created many barriers to free intercourse between nations. Nevertheless, international scientific cooperation continued as a decisive factor in the development which, shortly before the outbreak of the war, raised the prospect of releasing atomic energy on a vast scale.

The fear of being left behind was a strong incentive in various countries to explore, in secrecy, the possibilities of using such energy sources for military purposes. The joint American-British project remained unknown to me until, after my escape from occupied Denmark in the autumn of 1943, I came to England at the invitation of the British government. At that time I was taken into confidence

about the great enterprise which had already then reached an advanced stage.

Everyone associated with the atomic energy project was, of course, conscious of the serious problems which would confront humanity once the enterprise was accomplished. Quite apart from the role atomic weapons might come to play in the war, it was clear that permanent grave dangers to world security would ensue unless measures to prevent abuse of the new formidable means of destruction could be universally agreed upon and carried out.

As regards this crucial problem, it appeared to me that the very necessity of a concerted effort to forestall such ominous threats to civilization would offer quite unique opportunities to bridge international divergencies. Above all, early consultations between the nations allied in the war about the best ways jointly to obtain future security might contribute decisively to that atmosphere of mutual confidence which would be essential for co-operation on the many other matters of common concern.

In the beginning of 1944, I was given the opportunity to bring such views to the attention of the American and British governments. It may be in the interest of international understanding to record some of the ideas which at that time were the object of serious deliberation. For this purpose, I may quote from a memorandum which I submitted to President Roosevelt as a basis for a long conversation which he granted me in August 1944. Besides a survey of the scientific background for the atomic energy project, which is now public knowledge, this memorandum, dated July 3rd, 1944, contained the following passages regarding the political consequences which the accomplishment of the project might imply : "It certainly surpasses the imagination of anyone to survey the consequences of the project in years to come, where in the long run the enormous energy sources which will be available may be expected to revolutionize industry and transport. The fact of immediate preponderance is, however, that a weapon of an unparalleled power is being created which will completely change all future conditions of warfare.

"Quite apart from the question of how soon the weapon will be ready for use and what role it may play in the present war, this situation raises a number of problems which call for most urgent attention. Unless, indeed, some agreement about the control of the use of the new active materials can be obtained in due time, any temporary advantage, however great, may be outweighed by a perpetual menace to human security.

"Ever since the possibilities of releasing atomic energy on a vast scale came in sight much thought has naturally been given to the question of control, but the further the exploration of the scientific problems concerned is proceeding, the clearer it becomes that no kind of customary measures will suffice for this purpose and that especially the terrifying prospect of a future competition between nations about a weapon of such formidable character can only be avoided through a universal agreement in true confidence.

"In this connection it is above all significant that the enterprise, immense as it is, has still proved far smaller than might have been anticipated and that the progress of the work has continually revealed new possibilities for facilitating the production of the active materials and of intensifying their effects.

"The prevention of a competition prepared in secrecy will therefore demand such concessions regarding exchange of information and openness about industrial efforts including military preparations as would hardly be conceivable unless at the same time all partners were assured of a compensating guarantee of common security against dangers of unprecedented acuteness.

"The establishment of effective control measures will of course involve intricate technical and administrative problems, but the main point of the argument is that the accomplishment of the project would not only seem to necessitate but should also, due to the urgency of mutual confidence, facilitate a new approach to the problems of international relationship.

"The present moment where almost all nations are entangled in a deadly struggle

for freedom and humanity might at first sight seem most unsuited for any committing arrangement concerning the project. Not only have the aggressive powers still great military strength, although their original plans of world domination have been frustrated and it seems certain that they must ultimately surrender, but even when this happens, the nations united against aggression may face grave causes of disagreement due to conflicting attitudes towards social and economic problems.

"By a closer consideration, however, it would appear that the potentialities of the project as a means of inspiring confidence just under these circumstances acquire most actual importance. Moreover the momentary situation would in various respects seem to afford quite unique possibilities which might be forfeited by a postponement awaiting the further development of the war situation and the final completion of the new weapon.

,,"In view of these eventualities the present situation would seem to offer a most favourable opportunity for an early initiative from the side which by good fortune has achieved a lead in the efforts of mastering mighty forces of nature hitherto beyond human reach.

"Without impeding the importance of the project for immediate military objectives, an initiative, aiming at forestalling a fateful competition about the formidable weapon, should serve to uproot any cause of distrust between the powers on whose harmonious collaboration the fate of coming generations will depend.

"Indeed, it would appear that only when the question is taken up among the United Nations of what concessions the various powers are prepared to make as their contribution to an adequate control arrangement, it will be possible for anyone of the partners to assure themselves of the sincerity of the intentions of the others.

"Of course, the responsible statesmen alone can have the insight in the actual political possibilities. It would, however, seem most fortunate that the expectations for a future harmonious international co-operation which have found unanimous expression from all sides within the United Nations, so remarkably correspond to the unique opportunities which, unknown to the public, have been created by the advancement of science.

"Many reasons, indeed, would seem to justify the conviction that an approach with the object of establishing common security from ominous menaces without excluding any nation from participating in the promising industrial development which the accomplishment of the project entails will be welcomed, and be met with a loyal co-operation on the enforcement of the necessary far reaching control measures.

"Just in such respects helpful support may perhaps be afforded by the world-wide scientific collaboration which for years has embodied such bright promises for common human striving. On this background personal connections between scientists of different nations might even offer means of establishing preliminary and non-committal contact.

"It need hardly be added that any such remark or suggestion implies no underrating of the difficulty and delicacy of the steps to be taken by the statesmen in order to obtain an arrangement satisfactory to all concerned, but aim only at pointing to some aspects of the situation which might facilitate endeavours to turn the project to lasting benefit for the common cause".

The secrecy regarding the project which prevented public knowledge and open discussion of a matter so profoundly affecting international affairs added, of course, to the complexity of the task of the statesmen. With full appreciation of the extraordinary character of the decisions which the proposed initiave involved, it still appeared to me that great opportunities would be lost unless the problems raised by the atomic development were incorporated into the plans of the allied nations for the post-war world.

This viewpoint was elaborated in a supplementary memorandum in which also the

technical problem of control measures was further discussed. In particular, I attempted to stress that just the mutual openness, which now was obviously necessary for common security, would in itself promote international understanding and pave the way for enduring co-operation. This memorandum, dated March 24th 1945, contains, besides remarks which have no interest to-day, the following passages:

"Above all, it should be appreciated that we are faced only with the beginning of a development and that, probably within the very near future, means will be found to simplify the methods of production of the active substances and intensify their effects to an extent which may permit any nation possessing great industrial resources to command powers of destruction surpassing all previous imagination.

"Humanity will, therefore, be confronted with dangers of unprecedented character unless, in due time, measures can be taken to forestall a disastrous competition in such formidable armaments and to establish an international control of the manufacture and use of the powerful materials.

"Any arrangement which can offer safety against secret preparations for the mastery of the new means of destruction would, as stressed in the memorandum, demand extraordinary measures. In fact, not only would universal access to full information about scientific discoveries be necessary, but every major technical enterprise, industrial as well as military, would have to be open to international control.

"In this connection it is significant that the special character of the efforts which, irrespective of technical refinements, are required for the production of the active materials, and the peculiar conditions which govern their use as dangerous explosives, will greatly facilitate such control and should ensure its efficiency, provided only that the right of supervision is guaranteed.

"Detailed proposals for the establishment of an effective control would have to be worked out with the assistance of scientists and technologists appointed by the governments concerned, and a standing expert committee, related to an international security organization, might be charged with keeping account of new scientific and technical developments and with recommending appropriate adjustments of the control measures.

"On recommendations from the technical committee the organization would be able to judge the conditions under which industrial exploitation of atomic energy sources could be permitted with adequate safeguards to prevent any assembly of active material in an explosive state .

"As argued in the memorandum, it would seem most fortunate that the measures demanded for coping with the new situation, brought about by the advance of science and confronting mankind at a crucial moment of world affairs, fit in so well with the expectations for future intimate international co-operation which have found unanimous expression from all sides within the nations united against aggression.

"Moreover, the very novelty of the situation should offer a unique opportunity of appealing to an unprejudiced attitude, and it would even appear that an understanding about this vital matter might contribute most favourably towards the settlement of other problems where history and traditions have fostered divergent viewpoints.

"With regard to such wider prospects, it would in particular seem that the free access to information, necessary for common security, should have far-reaching effects in removing obstacles barring mutual knowledge about spiritual and material aspects of life in the various countries, without which respect and goodwill between nations can hardly endure.

"Participation in a development, largely ihitiated by international scientific collaboration and involving immense potentialities as regards human welfare, would also reinforce the intimate bonds which were created in the years before the war between scientists of different nations. In the present situation these bonds may

prove especially helpful in connection with the deliberations of the respective governments and the establishment of the control.

"In preliminary consultations between the governments with the primary purpose of inspiring confidence and relieving disquietude, it should be necessary only to bring up the problem of what the attitude of each partner would be if the prospects opened up by the progress of physical science, which in outline are common knowledge, should be realized to an extent which would necessitate exceptional action .

"In all the circumstances it would seem that an understanding could hardly fail to result, when the partners have had a respite for considering the consequences of a refusal to accept the invitation to co-operate, and convincing themselves of the advantages of an arrangement guaranteeing common security without excluding anyone from participation in the promising utilization of the new sources of material prosperity.

"All such opportunities may, however, be forfeited if an initiative is not taken while the matter can be raised in a spitit of friendly advice. In fact, a postponement to await further developments might, especially if preparations for competitive efforts in the meantime have reached an advanced stage, give the approach the appearance of an attempt at coercion in which no great nation can be expected to acquiesce .

"Indeed, it need hardly be stressed how fortunate in every respect it would be if, at the same time as the world will know of the formidable destructive power which has come into human hands, it could be told that the great scientific and technical advance has been helpful in creating a solid foundation for a future peaceful co-operation between nations".

Looking back on those days, I find it difficult to convey with sufficient vividness the fervent hopes that the progress of science might initiate a new era of harmonious co-operation between nations, and the anxieties lest any opportunity to promote such a development be forfeited.

Until the end of the war I endeavoured by every way open to a scientist to stress the importance of appreciating the full political implications of the project and to advocate that, before there could be any question of use of atomic weapons, international co-operation be initiated on the elimination of the new menaces to world security.

I left America in June 1945, before the final test of the atomic bomb, and remained in England, until the official announcement in August 1945 that the weapon had been used. Soon thereafter I returned to Denmark and have since had no connection with any secret, military or industrial, project in the field of atomic energy.

When the war ended and the great menaces of oppression to so many peoples had disappeared, an immense relief was felt all over the world. Nevertheless, the political situation was fraught with ominous forebodings. Divergencies in outlook between the victorious nations inevitably aggravated controversial matters arising in connection with peace settlements. Contrary to the hopes for future fruitful co-operation, expressed from all sides and embodied in the Charter of the United Nations, the lack of mutual confidence soon became evident.

The creation of new barriers, restricting the free flow of information between countries, further increased distrust and anxiety. In the field of science, especially in the domain of atomic physics, the continued secrecy and restrictions deemed necessary for security reasons hampered international co-operation to an extent which split the world community of scientists into separate camps.

Despite all attempts, the negotiations within the United Nations have so far failed in securing agreement regarding measures to eliminate the dangers of

atomic armament. The sterility of these negotiations, perhaps more than anything else, made it evident that a constructive approach to such vital matters of common concern would require an atmosphere of greater confidence.

Without free access to all information of importance for the interrelations between nations, a real improvement of world affairs seemed hardly imaginable. It is true that some degree of mutual openness was envisaged as an integral part of any international arrangement regarding atomic energy, but it grew ever more apparent that, in order to pave the way for agreement about such arrangements, a decisive initial step towards openness had to be made.

The ideal of an open world, with common knowledge about social conditions and technical enterprises, including military preparations, in every country, might seem a far remote possibility in the prevailing world situation. Still, not only will such relationship between nations obviously be required for genuine co-operation on progress of civilization, but even a common declaration of edherence to such a course would create a most favourable background for concerted efforts to promote universal security. Moreover, it appeared to me that the countries which had pioneered in the new technical development might, due to their possibilities of offering valuable information, be in a special position to take the initiative by a direct proposal of full mutual openness.

I thought it appropriate to bring these views to the attention of the American government without raising the delicate matter publicly. On visits to the United States in 1946 and in 1948 to take part in scientific conferences, I therefore availed myself of the opportunity to suggest such an initiative to American statesmen. Even of it involves repetition of arguments already presented, it may serve to give a clearer impression of the ideas under discussion on these occasions to quote a memorandum, dated May 17th, 1948, submitted to the Secretary of State as a basis for conversations in Washington in June 1948 :

"The deep-rooted divergencies in attitudes to many aspects of human relationship which have grown out of social and political developments in the last decades, were bound to present a serious strain on international relations at the conclusion of the second world war. While, during the war, the efforts in common defense largely distracted attention from such divergencies, it was clear that the realization of the hopes acclaimed from all the nations united against aggression of a whole-hearted co-operation in true confidence would demand a radically new approach to international relations.

"The necessity of a readjustment of such relations was even further accentuated by the great scientific and technical developments which hold out bright prospects for the promotion of human welfare, but at the same time have placed formidable means of destruction in the hands of man. Indeed, just as previous technical progress has led to the recognition of need for adjustments within civilized societies, many barriers between nations which hitherto were thought necessary for the defense of national interests would now obviously stand in the way of common security.

"The fact that this challenge to civilization presents the nations with a matter of the deepest common concern should offer a unique opportunity for seeking continued co-operation on vital problems. Already during the war, it was, therefore, felt that a favourable foundation for later developments might be created by an early initiative aimed at inviting confidence by making all partners aware of the actual situation which would have to be faced, and by assuring them of willingness to share in the far-reaching concessions as to accustomed national prerogatives which Would be demanded from every side.

"In the years which have passed since the war, the divergencies in outlook have manifested themselves ever more clearly and a most desperate feature of the present situation is the extent to which the barring of intercourse has led to distortion of facts and motives, resulting in increasing distrust and suspicion between nations and

even between groups within many nations. Under these circumstances the hopes embodied in the establishment of the United Nations Organization have met with repeated great disappointments and, in particular, it has not been possible to obtain consent as regards control of atomic energy armaments.

"In this situation with deepening cleavage between nations and with spreading anxiety for the future, it would seem that the turning of the trend of events requires that a great issue be raised, suited to invoke the highest aspirations of mankind. Here it appears that the stand for an open world, with unhampered opportunities for common enlightenment and mutual understanding, must form the background for such an issue. Surely, respect and goodwill between nations cannot endure without free access to information about all aspects of life in every country.

"Moreover, the promises and dangers involved in the technical advances have now most forcibly stressed the need for decisive steps towards openness as a primary condition for the progress and protection of civilization. The appreciation of this point, it is true, underlies the proposals to regulate co-operation on the development of the new resources, brought before the United Nations Atomic Energy Commission, but just the difficulty experienced in obtaining agreement under present world conditions would suggest the necessity of centering the issue more directly on the problem of openness.

"Under the circumstances it would appear that most careful consideration should be given to the consequences which might ensue from an offer, extended at a well-timed occasion, of immediate measures towards openness on a mutual basis. Such measures should in some suitable manner grant access to information, of any kind desired, about conditions and developments in the various countries and would thereby allow the partners to form proper judgment of the actual situation confronting them.

"An initiative along such lines might seem beyond the scope of conventional diplomatic caution; yet it must be viewed against the back-ground that, if the proposals should meet with consent, a radical improvement of world affairs would have been brought about, with entirely new opportunities for co-operation in confidence and for reaching agreement on effective measures to eliminate common dangers.

"Nor should the difficulties in obtaining consent be an argument against taking the initiative since, irrespective of the immediate response, the very existence of an offer of the kind in question should deeply affect the situation in a most promising direction. In fact, a demonstration would have been given to the world of preparedness to live together with all others under conditions where mutual relationships and common destiny would be shaped only by honest conviction and good example.

"Such a stand would, more than anything else, appeal to people all over the world, fighting for fundamental human rights, and would greatly strengthen the moral position of all supporters of genuine international co-operation. At the same time, those reluctant to enter on the course proposed would have been brought into a position difficult to maintain since such opposition would amount to a confession of lack of confidence in the strength of their own cause when laid open to the world.

"Altogether, it would appear that, by making the demand for openness a paramount issue, quite new possibilities would be created, which, if purposefully followed up, might bring humanity a long way forward towards the realization of that co-operation on the progress of civilization which is more urgent and, notwithstanding present obstacles, may still be within nearer reach than ever before".

The consideration in this memorandum may appear utopian, and the difficulties of surveying complications of non-conventional procedures may explain the hesitations of governments in demonstrating adherence to the course of full mutual openness. Nevertheless, such a course should be in the deepest interest of all nations, irrespective of differences in social and economic organization, and the hopes and

aspirations for which it was attempted to give expression in the memorandum are no doubt shared by people all over the world.

While the present account may perhaps add to the general recognition of the difficulties with which every nation was confronted by the coincidence of a great upheaval in world affairs with a veritable revolution as regards technical resources, it is in no way meant to imply that the situation does not still offer unique opportunities. On the contrary, the aim is to point to the necessity of reconsidering, from every side, the ways and means of co-operation for avoiding mortal menaces to civilization and for turning the progress of science to lasting benefit of all humanity.

Within the last years, world-wide political developments have increased the tension between nations and at the same time the perspectives that great countries may compete about the possession of means of annihilating populations of large areas and even making parts of the earth temporarily uninhabitable have caused wide-spread confusion and alarm.

As there can hardly be question for humanity of renouncing the prospects of improving the material conditions for civilization by atomic energy sources, a radical adjustment of international relationship is evidently indispensable if civilization shall survive. Here, the crucial point is that any guarantee that the progress of science is used only to the benefit of mankind presupposes the same attitude as is required for co-operation between nations in all domains of culture.

Also in other fields of science recent progress has confronted us with a situation similar to that created by the development of atomic physics. Even medical science, which holds out such bright promises for the health of people all over the world, has created means of extinguishing life on a terrifying scale which imply grave menaces to civilization, unless universal confidence and responsibility can be firmly established.

The situation calls for the most unprejudiced attitude towards all questions of international relations. Indeed, proper appreciation of the duties and responsibilities implied in world citizenship is in our time more necessary than ever before. On the one hand, the progress of science and technology has tied the fate of all nations inseparably together, on the other hand, it is on a most different cultural background that vigorous endeavours for national selfassertion and social development are being made in the various parts of our globe.

An open world where each nation can assert itself solely by the extent to which it can contribute to the common culture and is able to help others with experience and resources must be the goal to be put above everything else. Still, example in such respects can be effective only if isolation is abandoned and free discussion of cultural and social developments permitted across all boundaries.

Within any community it is only possible for the citizens to strive together for common welfare on a basis of public knowledge of the general conditions in the country. Likewise, real co-operation between nations on problems of common concern presupposes free access to all information of importance for their relations. Any argument for upholding barriers for information and intercourse, based on concern for national ideals or interests, must be weighed against the beneficial effects of common enlightenment and the relieved tension resulting from openness.

In the search for a harmonious relationship between the life of the individual and the organization of the community, there have always been and will ever remain many problems to ponder and principles for which to strive. However, to make it possible for nations to benefit from the experience of others and to avoid mutual misunderstanding of intentions, free access to information and unhampered opportunity for exchange of ideas must be granted everywhere.

In this connection it has to be recognized that abolition of barriers would imply greater modifications in administrative

practices in countries where new social structures are being built up in temporary seclusion than in countries with long traditions in governmental organization and international contacts. Common readiness to assist all peoples in overcoming difficulties of such kind is, therefore, most urgently required.

The development of technology has now reached a stage where the facilities for communication have provided the means for making all mankind a co-operating unit, and where at the same time fatal consequences to civilization may ensue unless international divergencies are considered as issues to be settled by consultation based on free access to all relevant information.

The very fact that knowledge is in itself the basis for civilization points directly to openness as the way to overcome the present crisis. Whatever judicial and administrative international authorities may eventually have to be created in order to stabilize world afairs, it must be realized that full mutual openness, only, can effectively promote confidence and guarantee common security.

Any widening of the borders of our knowledge imposes an increased responsibility on individuals and nations through the possibilities it gives for shaping the conditions of human life. The forceful admonition in this respect which we have received in our time cannot be left unheeded and should hardly fail in resulting in common understanding of the seriousness of the challenge with which our whole civilization is faced. It is just on this background that quite unique opportunities exist to-day for furthering co-operation between nations on the progress of human culture in all its aspects.

I turn to the United Nations with these considerations in the hope that they may contribute to the search for a realistic approach to the grave and urgent problems confronting humanity. The arguments presented suggest that every initiative from any side towards the removal of obstacles for free mutual information and inter-course would be of the greatest importance in breaking the present deadlock and encouraging others to take steps in the same direction. The efforts of all supporters of international co-operation, individuals as well as nations, will be needed to create in all countries an opinion to voice, with ever increasing clarity and strength, the demand for an open world.

(This letter dated Copenhagen, 9 June 1950, was delivered to the Secretary General of the United Nations on 12 June, 1950 and at the same time released for publication.)

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# SCIENTIFIC WORKERS AND SOCIETY

**by Lord Boyd-Orr.**

Lord John Boyd-Orr, F.R.S., Nobel prize winner, is President of the British Association of Scientific Workers. At the annual Council meeting in May 1950, in his presidential address, he examined the social function of the scientific worker. He said :

"The work of men and women like you in this and other countries is rapidly advancing knowledge and this knowledge is creating social, economic and political problems. You have, therefore, a certain amount of responsibility to warn not only governments and administrators in industry, but also the people of the world what the advancement of knowledge means. What matters is to prevent the new knowledge being applied to wrong ends through ignorance. In stating these problems, I would like to give you a warning. While in private life we can be Conservatives, Liberals, and so on, as scientists, we must consider these problems objectively to see what ought to be done to enable the advances to be applied for the benefit of human welfare. We must not allow politics to bias our scientific judgment.

"You are all anxious to increase the advancement of knowledge, but the knowledge we have already is so great that the difficulty is not to get new knowledge, but to get the wisdom and the goodwill to apply the knowledge we have. The physicists have given us the atomic bomb, the bacteriologists have given us bacteriological weapons of war. Now they are working day and night to give us the hydrogen bomb — and so research goes on. I say that scientists who are producing these great powers have the responsibility to warn people of what may happen through the misuse of these powers. I am glad to say that scientists to-day are doing that to a much greater extent than when I was engaged in science and was told to keep my mouth shut.

"The atomic bomb has so seized the imagination of the people of the world, especially in America, that they are rather hypnotized by it. They think that the only difficulty at the present time is to see what is to be done with this bomb. I agree that atomic knowledge is rushing forward and many of us wish that it had never been invented. These things tend to cause an obsession about war and tend to make us think that the only problem is how to get the atomic bomb outlawed.

"But science has advanced in other directions. Advances in technology have enabled us to produce goods in such abundance that there is difficulty in getting markets for them. It is my opinion that the assembly line is as great a danger to human society as the atomic bomb, unless we can get wisdom to use that assembly line and to prevent another economic crisis such as occurred in 1929-30. During the last war, the U.S.A. and Canada were outside the battle area and there was a market for everything they produced. Industrial activity in these two countries increased by 100 %, agricultural products increased by 35%. Since the war, production has gone up in other countries. In this country, we produce 30 % above pre-war level. In Sweden, production has gone up by 47 %. There is difficulty in finding markets. When Japan and Germany come back into the world market the big problem is how we are going to arrange international markets for all these products so that they can be disposed of and consumed, and prevent a breakdown of the economic system because it cannot carry the great wealth which modern science has made possible.

"Science can produce atomic bombs which threaten war. Science can produce an abundance of things men need. Bring these two things together and you can provide the ways and means for getting what science can produce dispersed and consumed. Then you will go far to lessen the danger of war, because half of the people of the world today suffers premature death for the lack of food and other basic necessities of life,

including an environment free from preventable disease. Half the population of the world has only an expectation of life of 35 to 40 years.

"If modern science could be applied on a global scale to meet the needs of all mankind, what would happen? You would bring social content and the prospect of peace to the people of Asia. The upsurge in Asia which we attribute entirely to Communism is fundamentally a revolt against hunger and poverty. People in Asia have changed during the last fifty years. Now they have realised that poverty and hunger is no longer inevitable and they are demanding that they should have a standard of living more like ours. That movement you cannot stop with guns. When you try to do so, all you do is to create a racial feeling which increases the determination to get rid of the control of the white man.

"If you get a global plan to co-operate, as the nations promised to do in the Atlantic Charter, and could say to these people in revolt, We are going to do this for you - to develop your resources and increase your standard of living , that would offer the solution not only to the social unrest in Asia. It would also offer the economic solution to the great capacity for industrial production in the highly centralised countries like the U.S. and the U.K. If we can assure that there would be a market for everything we could produce this would remove the fear of the breakdown of world markets and rising unemployment. That is the problem.

"The wealthy nations ask why should they help people for whom they have no responsibility. You cannot make the rest of the world richer by making one country poorer. You can only do it by an all-round increase of the world's wealth in which all nations will share. In the 19th Century when we had the industrial lead which America now has, we created credits and made loans to all countries and sent them the goods. Their wealth was increased and their standard of living, and we shared in it.

"The world today is too small for the U.S. or any other country to pursue this policy. Any country trying to do that is under suspicion of world economic domination. The only way to do it is by the nations getting together through the international agencies of the U.N. By such an expanding world economy we will be able to solve our economic difficulties."

Lord Boyd-Orr then discussed relations between the Great Powers, and said that they ought to get together and talk about wheat and coal, and timber and cotton where they could define their terms exactly. In this way, they could show that the new world club of nations is working for the application of science to the welfare of mankind.

Finally, he expressed the hope "that the Association will regard as its main function the study of the implications of science to human society, to the great problems which the impact of science on human society has caused. I hope it will study them objectively and not be afraid to say what is the truth."

# List of Papers presented at the Fourth World Power Conference, London, 1950.

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2. Energy Resources of Canada and their Development : DOMINION WATER & POWER BUREAU & others *(see abstract 111)*
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*SECTION B1*

**Preparation of Solid Fuels - Coal**

1. Coal Preparation in Canada: SWARTZMAN
2. The Problem of Coal Preparation: GROUNDS
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4. Coal Specification: MOFFAT & others
5. The Fuel Situation in India: WHITAKER
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10. The Mechanical Preparation of Coal and its Relationship to the Power Industry: LASKOWSKI

*SECTION B2*

**Preparation of Solid Fuels - Lignite, Brown Coal and Peat**

1. The Preparation and Utilization of Victorian Brown Coal: ROBERTS
2. The Preparation and Utilization of Low-grade Fuels: SIMEK & MEJSTRIK
3. Lignite: Its Processing and Utilization: POPOVICH
4. The Winning and Utilization of Peat in Ireland: MAGUIRE
5. Production of Milled Peat and Briquettes in Sweden: UDDGREN & TONISBERG
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London W.1., England

BCGA – BRITISH COMMERCIAL GAS ASSOCIATION
Gas Industry House
1 Grosvenor Place
London S.W.1., England

CF — CORONET FILMS
65 E. South Water Street
Chicago, Ill., USA

CFU – CROWN FILM UNIT
Beaconsfield, Buckinghamshire,
England

CSF – CZECHOSLOVAK STATE FILM
Vaclavske Nemesti 43
Prague 2, C.S.A.

CD – C.G. DUVENAL
Quai Gustave Ador 40
Geneva, Switzerland

COI – Central Office of Information
*(See* **B C O I** above)

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GMC – GENERAL MOTORS CORPORATION
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HPCO – Hydro-electric Power
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IFI – INFORMATION FILMS OF INDIA
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Broadcasting, New Delhi, INDIA

KB – KNOWLEDGE BUILDERS
625 Madison Avenue
New York 22, N.Y., USA

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NWR – NORFOLK & WESTERN RAILWAY
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USDA – UNITED STATES DEPARTMENT OF
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Motion Picture Bureau
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USDI – UNITED STATES DEPARTMENT OF THE
INTERIOR BUREAU OF RECLAMATION
Washington 25, D.C., USA
– BUREAU OF MINES, 4800 Forbes Street,
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USDS – UNITED STATES DEPARTMENT OF STATE
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